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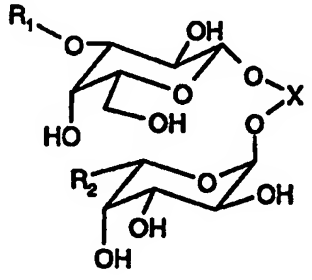
(54) Title: DIGLYCOSYLATED 1,2-DIOLS AS MIMETICS OF SIALYL-LEWIS X AND SIALYL-LEWIS A

(57) Abstract

Compounds of formula (I) in which X is the residue of a non-glycosidic aliphatic 1,2-diol; R_1 is an S-configurated methyl substituted with one carboxyl residue and one other substituent; and R_2 is hydrogen, C_1-C_{12}alkyl or C_6aryl; as mimetics of sialyl-Lewis X and sialyl-Lewis A.



(I)

Diglycosylated 1,2-diols as mimetics of sialyl-Lewis X and sialyl-Lewis A.

The present invention relates to mimetics of sialyl-Lewis X and sialyl-Lewis A, in which, in the natural tetrasaccharide, the neuraminic acid residue is replaced by an S-configurated methyl substituted with one carboxyl residue and one other substituent and the N-acetyl-glucosamine residue is replaced by a non-glycosidic residue of a 1,2-diol, to processes for the preparation of these compounds and to the use of these mimetics in therapeutic methods.

The complex process of inflammation, which takes place in several stages, is the body's natural reaction to injuries in which, for example, there is also invasion by infectious agents. Under the influence of cytokines, the endothelium which lines the blood vessels expresses adhesion proteins on its surface. The P and E selectins bring about, by a protein-carbohydrate interaction with glycolipids and glycoproteins on the leukocyte membrane, the so-called "rolling" of leukocytes. The latter are slowed down by this process, and there is activation of certain proteins (integrins) on their surface which ensure firm adhesion of the leukocytes to the endothelium. This is followed by migration of the leukocytes into the damaged tissue.

When this process takes place in a controlled manner, the damage is eliminated after a certain time without major adverse effects remaining. It is otherwise in the case of certain acute and chronic inflammatory processes, in which the migration of leukocytes takes place in an uncontrolled manner, which leads to severe damage to the body. This is the case in disorders such as cardiogenic shock, myocardial infarct, thrombosis, rheumatism, psoriasis, dermatitis, acute respiratory distress syndrome and metastatic cancer [Dasgupta, F., Rao, B.N.N., Exp. Opin. Invest. Drugs 3:709-724 (1994)].

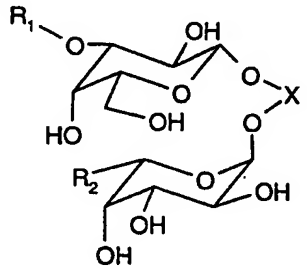
Several approaches to the development of medicaments which intervene at various points in these unwanted processes have already been pursued [Dasgupta, F., Rao, B.N.N., Exp. Opin. Invest. Drugs 3:709-724 (1994)]. The aim of one route is to prevent the interaction between P and E selectins and their receptors on the leukocyte membrane, thus to prevent the "rolling", by mimetics of the corresponding epitopes. This also results in suppression of

the subsequent processes. One of the smallest carbohydrate epitopes as ligand for E selectin is sialyl-Lewis X [neuraminic acid-α(2→3)-galactose-β(1→4)-(fucose-α(1→3))-N-acetylglucosamine (sLe^x)].

EP-A-0 579 196 proposed as compounds competing with the natural ligands for binding to E selectin mimetics of sLe^x in which the neuraminic acid residue is replaced by a lactic acid residue. WO 93/10796 describes compounds which comprise in place of the neuraminic acid residue the residue of an α-hydroxy acid. WO 93/23031 discloses mimetics in which the N-acetylglucosamine residue (GlcNAc residue) is replaced by an R,R-1,2-cyclohexane-dioxy. However, it is common to all these compounds that the binding affinity between them and the E selectin is increased only inconsiderably compared with that of sLe^x, or is in fact worse, and is insufficient for a therapeutic effect.

It has now been found, surprisingly, that simultaneous replacement of the neuraminic acid residue by an S-configurated methyl substituted with one carboxyl residue and one other substituent and of the N-acetylglucosamine residue by a non-glycosidic residue of an aliphatic diol results in an unexpectedly high binding affinity of the resulting mimetic. The novel compounds additionally represent a structural and chemical simplification, have a lower molecular weight and can be obtained in larger quantities by methods with low synthetic complexity.

The present invention relates to compounds of the formula I



(I)

in which

X is the residue of a non-glycosidic aliphatic 1,2-diol;

R_1 is an S-configurated methyl substituted with one carboxyl residue and one other substituent; and

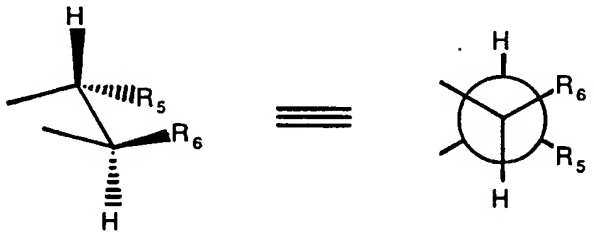
R_2 is hydrogen, C_1-C_{12}alkyl or C_6aryl; where the alkyl and the aryl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal; including their physiologically tolerated salts.

Preferred aliphatic residues X are linear or branched C_2-C_{20}-, preferably C_2-C_{12}- and particularly preferably C_2-C_6alkylene and -alkenylene, C_3-C_{12}-, preferably C_3-C_8- and particularly preferably C_5-C_7cycloalkylene and cycloalkenylene, and C_3-C_{11}-, preferably C_3-C_7- and particularly preferably C_3-C_5heterocycloalkylene and heterocycloalkenylene with hetero atoms selected from the group of -O-, -S- and -N-.

The residue X can contain substituents such as OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide,

carbhydrazide, carbohydroxamic acid and amidocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

In a preferred embodiment of the present invention, X is the residue of a 1,2-diol corresponding to formula II



(II)

in which

R_5 and R_6 are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; or R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_3-C_{12}-cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group -O-, -S- and -N-;

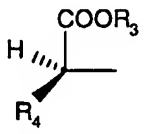
where alkyl, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkylene, cycloalkenylene, heterocycloalkylene and heterocycloalkenylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl,

C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

The other substituent in R_1 has preferably 1 to 20, more preferably 1 to 16, particularly preferably 1 to 12, and especially preferably 1 to 8, C atoms. The other substituent is preferably selected from the group consisting of unsubstituted and substituted C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl and C_7-C_{10}heteroaralkenyl. The other substituent is particularly preferably substituted methyl, or 2-substituted ethyl or cyclohexyl. Examples of suitable substituents are the substituents mentioned above in the definition of R_2, especially OH, halogen (F, Cl or Br), carboxyl, $-SO_3H$, $C(O)OM_y$, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, or C_1-C_{12}alkyl, C_1-C_{12}alkoxy, nitro, $-NH_2$, primary amino with 1 to 20 C atoms, secondary amino with 2 to 30 C atoms, cyano, C_3-C_8cycloalkyl, C_3-C_6heterocycloalkyl, C_6-C_{10}aryl, C_3-C_9heteroaryl, C_7-C_{16}heteroaralkyl, where the hetero atoms are selected from the group of O, S and N atoms, and carbamide, carbamate, carbhydrazide, sulfonamide, sulfonhydrazide or aminocarbonylamide, whose N atoms are unsubstituted or substituted by a hydrocarbon group or hydroxy-hydrocarbon group with 1 to 20 C atoms. The hydrocarbon groups and heterohydrocarbon groups in turn are unsubstituted or substi-

tuted, for example with C_1-C_6alkyl, C_1-C_6alkoxy, carboxyl, halogen (F, Cl or Br), -OH, -CN or $-NO_2$.

In a particular embodiment of the compounds of the formula I, R_1 corresponds to a group of the formula III,



(III),

in which

R_3 is hydrogen or M_y; and

R_4 is C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl or C_7-C_{10}heteroaralkenyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

For the purposes of the present invention, a metal is to be understood as meaning an alkali metal [for example lithium (Li), sodium (Na), potassium (K), rubidium (Rb) and caesium (Cs)], an alkaline earth metal [for example magnesium (Mg), calcium (Ca) and strontium (Sr)] or manganese (Mn), iron (Fe), zinc (Zn) or silver (Ag). Physiologically tolerated salts are to be understood as meaning, in particular, the alkali metal and alkaline earth metal salts, for example sodium, potassium, magnesium and calcium salts. Sodium and potassium ions and their salts are preferred.

Halogen is to be understood as meaning a representative of the group consisting of fluorine, chlorine, bromine and iodine. Fluorine, chlorine and bromine are preferred, especially fluorine and chlorine.

Alkyl can be linear or branched, preferably branched once or twice in the α position. Some examples of alkyl, which preferably contains 1 to 12 C atoms, are methyl, ethyl and the isomers of propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl and dodecyl. Preferred alkyl groups are methyl, ethyl, n- and i-propyl, n-, i- and t-butyl.

Examples of alkenyl are allyl, but-1-en-3-yl or -4-yl, pent-3- or 4-en-1-yl or -2-yl, hex-3- or -4- or -5-en-1-yl or -2-yl and (C_1-C_4alkyl)CH=CH-CH_2-.

Cycloalkyl and cycloalkenyl can contain preferably 5 to 8 and particularly preferably 5 or 6 ring carbon atoms. Examples of cycloalkyl are cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, cyclononyl, cyclodecyl, cycloundecyl and cyclododecyl. Cyclohexyl is a particularly preferred cycloalkyl group. Examples of cycloalkenyl are cyclopropenyl, cyclobutenyl, cyclopentenyl, cyclohexenyl, cycloheptenyl, cyclooctenyl, cyclononenyl, cyclodecenyl, cycloundecenyl and cyclododecenyl. Cyclohexenyl is a particularly preferred cycloalkenyl group.

Examples of alkylene are ethylene, 1,2-propylene, 1,2- or 2,3-butylene, 1,2- or 2,3-pentylene, 1,2-, 2,3- or 3,4-hexylene. Examples of cycloalkylene are 1,2-cyclopropylene, 1,2-cyclobutylene, 1,2-cyclopentylene, 1,2-cyclohexylene, 1,2-cycloheptylene and 1,2-cyclooctylene. Examples of heterocycloalkylene are pyrrolidinylene, piperidinylene, tetrahydrofuranylene, di- and tetrahydropyranylene.

Examples of heterocycloalkyl are derived from pyrrolidine, imidazolidine, oxazolidine, pyrazolidine, piperidine, piperazine and morpholine. Examples of heterocycloalkenyl are derived from 2- and 3-pyrroline, oxazoline, 2- and 4-imidazoline and 2- and 3-pyrazoline.

For the purposes of the present invention, aryl or heteroaryl is a five- or six-membered ring or a bicycle consisting of two condensed six- or five-membered rings or one six-membered and one five-membered ring, and in the case of heteroaryl one or more C atoms may be replaced, independently of one another, by an atom selected from the group consisting of oxygen, nitrogen and sulfur. Examples are derived from benzene, naphthalene, indene, furan, pyrrole, pyrazole, imidazole, isoxazole, oxazole, furazan, thiadiazole, thiophene, thiazole, oxadiazole, triazole, indole, indazole, purine, benzimidazole, benzoxazole, benzothiazole, pyran, pyridine, pyridazine, triazine, pyrimidine, pyrazine, isoquinoline, cinnoline, phthalazine, quinoline, quinazoline, pterdine, benzotriazine or quinoxaline. Aryl is preferably naphthyl and phenyl. Phenyl is particularly preferred. Heteroaryl is preferably furanyl, pyridinyl and pyrimidinyl.

Aralkyl preferably has 7 to 12 C atoms and can be phenyl-C_nH_{2n}- with n equal to a number from 1 to 6. Examples are benzyl, phenylethyl or phenylpropyl. Benzyl and 2-phenylethyl are preferred. Aralkenyl is preferably unsubstituted phenyl-CH=CH-CH_2- (cinnamyl) and cinnamyl is substituted on the phenyl by a substituent selected from the group consisting of OH, halogen, COOH, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_8heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and NO_2, C_1-C_{12}primary amino, C_2-C_{20}secondary amino, amino and CN.

Heteroaralkyl and heteroaralkenyl are preferably C_4-C_5heteroarylmethyl and C_4-C_5heteroarylethenyl with one or two hetero atoms from the group of O and N, and the heteroaryl can comprise the abovementioned heteroaryl residues.

Alkoxy can be linear or branched, preferably branched once or twice in the α position. Some examples of alkoxy, which preferably contains 1 to 12 C atoms, are methoxy, ethoxy and the isomers of propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, nonoxy, decoxy, undecoxy and dodecoxy. Preferred alkoxy groups are methoxy and ethoxy.

Examples of aryloxy and aralkoxy are phenoxy and benzyloxy. Heteroaryloxy is preferably furanyloxy, pyridinyloxy and pyrimidinyloxy.

The primary amino preferably contains 1 to 12, particularly preferably 1 to 6, C atoms. Some examples are methyl-, ethyl-, hydroxyethyl-, n- or i-propyl-, n-, i- or t-butyl-, pentyl-, hexyl-, cyclopentyl-, cyclohexyl-, phenyl-, methylphenyl-, benzyl- and methylbenzylamino. The secondary amino preferably contains 2 to 14, particularly preferably 2 to 8, C atoms. Some examples are dimethyl-, diethyl-, methylethyl-, di-n-propyl-, di-i-propyl-, di-n-butyl-, diphenyl-, dibenzylamino, morpholino, piperidino and pyrrolidino.

NH_2, primary amino, secondary amino, carbamide, carbamate, carbhydrazide, sulfonamide, sulfonhydrazide and aminocarbonylamide preferably correspond to a group $R_8C(O)(NH)_pN(R_9)$-, -$C(O)(NH)_pNR_8R_9$, $R_8OC(O)(NH)_pN(R_9)$-, $R_8R_{40}NC(O)(NH)_pN(R_9)$-, -$OC(O)(NH)_pNR_8R_9$, -$N(R_{40})C(O)(NH)_pNR_8R_9$, $R_8S(O)_2(NH)_pN(R_9)$-; -$S(O)_2(NH)_pNR_8R_9$; $R_8R_{40}NS(O)_2N(R_9)$- or -$NR_{40}S(O)_2NR_8R_9$, in which R_8, R_9 and R_{40} are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_1-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, C_6-C_{15}heteroaralkyl, C_6-C_{15}heteroaralkenyl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, or $R_{8'}R_{9'}N$ in which $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, OH, SO_3M_y, OSO_3M_y, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl,

C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl, in turn are unsubstituted or substituted by one of the abovementioned substituents; p is 0 or 1 and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal; or R_8 and R_9 or $R_{8'}$ and $R_{9'}$ or R_8 and R_{40} in the case of -NR_8R_9 or -$NR_{8'}R_{9'}$ or $R_8R_{40}N$- together are tetramethylene, pentamethylene, -$(CH_2)_2$-O-$(CH_2)_2$-, -$(CH_2)_2$-S-$(CH_2)_2$- or -$(CH_2)_2$-NR_7-$(CH_2)_2$-, and R_7 is H, C_1-C_6alkyl, C_7-C_{11}aralkyl, C(O)R_{s2} or sulfonyl.

The sulfonyl substituent corresponds, for example, to the formula R_{10}-SO_2- in which R_{10} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)OR_{s1}, OC(O)R_{s4}, C(O)R_{s2}, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are substituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Preferred compounds of the formula I are those compounds in which X corresponds to a group of the formula II in which R_5 and R_6

(a) are unsubstituted or substituted by C_1-C_{12}alkyl, for example methyl, ethyl, or C_1-C_{12}alkoxy, for example methoxy, ethoxy;

(b) are, together with the group -CH-CH-, a 5- to 8-membered carbocycle, and particularly preferably, a 5- or 6-membered carbocycle, and are very particularly preferably R,R-1,2-cyclohexylene;

(c) are, together with the group -CH-CH-, a 5- to 8-membered heterocarbocycle, and particularly preferably a 5- or 6-membered heterocarbocycle with nitrogen as hetero atom, and are very particularly preferably R,R-3,4-piperidylene;

(d) are, independently of one another, hydrogen, unsubstituted C_1-C_{12}alkyl or C_1-C_{12}alkyl which is substituted by a substituent selected from the group consisting of -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_3-C_{12}cycloalkyl, C_1-C_6alkoxy, phenyloxy and benzyloxy; unsubstituted C_3-C_{12}cycloalkyl or C_3-C_{12}cycloalkyl which is substituted by a substituent selected from the group consisting of -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_1-C_6alkyl, C_1-C_6alkoxy, phenyloxy and benzyloxy; C_6-C_{10}aryl which is unsubstituted or substituted by -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_1-C_6alkyl or C_1-C_6alkoxy; C_3-C_9heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms; or C_7-C_{12}aralkyl which is unsubstituted or substituted by -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_1-C_6alkyl or C_1-C_6alkoxy;

(e) are, together with the group -CH-CH-, a 5- to 12-membered carbocycle or 5- or 6-membered heterocarbocycle with a hetero atom selected from the group consisting of oxygen and nitrogen atoms; or

(f) are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_4-C_{12}cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group of -O-, -S- and -N-;

where cycloalkylene, cycloalkenylene, heterocycloalkylene and heterocycloalkenylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)OR_{s1}, OC(O)R_{s4}, C(O)R_{s2}, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4}

is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Particularly preferred compounds are those in which X corresponds to a group of the formula II in which R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene or C_2-C_{11}heterocycloalkylene with nitrogen as hetero atom; where cycloalkylene and heterocycloalkylene are unsubstituted or substituted by one or more of the above substituents.

Particularly preferred compounds are those in which R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene or C_2-C_{11}heterocycloalkylene with nitrogen as hetero atom;
where cycloalkylene and heterocycloalkylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, NR_8R_9, C_1-C_{12}alkyl, $R_8C(O)(NH)_pN(R_9)$-, $-C(O)(NH)_pNR_8R_9$, $R_8S(O)_2(NH)_pN(R_9)$-; $R_8R_{40}NC(O)(NH)_pN(R_9)$-, $R_8OC(O)(NH)_pN(R_9)$-, $-OC(O)(NH)_pNR_8R_9$, and R_{10}-SO_2-,
in which R_8, R_9, R_{10} and R_{40} are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_1-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, C_6-C_{15}heteroaralkyl, C_6-C_{15}heteroaralkenyl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide; R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-

C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s2} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, heteroaralkyl, aralkenyl and heteroaralkenyl as substituents in turn are unsubstituted or substituted by one of the abovementioned substituents; p is 0 or 1 and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

R_8 and R_9 are, in particular, independently of one another hydrogen; C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl, C_6-C_{10}aryl, C_7-C_{16}aralkyl with 1 to 6 C atoms in the alkylene group and C_6-C_{10}aryl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, for example diphenylmethyl or 2,2-diphenylethyl, where R_8 and R_9 are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, COOH, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, C_6-C_{10}aryloxy, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, NO_2, amino, primary amino, secondary amino and CN, R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

R_{10} corresponds, in particular, to C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl, C_6-C_{10}aryl, C_7-C_{16}aralkyl with 1 to 6 C atoms in the alkylene group and C_6-C_{10}aryl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6alkyl, for example diphenylmethyl or 2,2-diphenylethyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, COOH, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, NO_2, amino, primary amino, secondary amino and CN; where R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Furthermore, R_{10} is preferably C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl, C_6-C_{10}aryl, C_7-C_{16}aralkyl with 1 to 6 C atoms in the alkylene group and C_6-C_{10}aryl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, nitro, amino, primary amino, secondary amino and cyano; or C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6alkyl, for example diphenylmethyl or 2,2-diphenylethyl.

In a preferred subgroup of compounds, R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene or C_2-C_{11}heterocycloalkylene with nitrogen as hetero atom; where cycloalkylene and heterocycloalkylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, NH_2, C_1-C_{12}alkyl, $R_8C(O)N(R_9)$-, $-C(O)NR_8R_9$, $R_8S(O)_2N(R_9)$-; $R_8OC(O)N(R_9)$- and R_{10}-SO_2-, in which R_9 is hydrogen and R_8 is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, which are unsubstituted or substituted by one or more C_1-C_{12}alkoxy; R_{10} is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more C_1-C_{12}alkyl; R_{s1} and R_{s4} are C_1-C_{12}alkyl and R_{s2} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkenyl, C_3-C_{12}cycloalkyl or C_6-C_{10}aryl, and alkyl, cycloalkenyl, cycloalkyl and aryl as substituents in turn are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1'}$ and $OC(O)R_{s4'}$ where $R_{s1'}$ is M_y or C_1-C_{12}alkyl and $R_{s4'}$ is C_1-C_{12}alkyl; y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Particularly preferred compounds within this group are those in which R_5 and R_6 are, together with the -CH-CH- group, cyclohexylene.

Another subgroup of preferred compounds are those compounds in which R_5 and R_6 are, together with -CH-CH- group, piperidylene.

Particularly preferred compounds are those in which R_5 and R_6 are, together with the -CH-CH- group, piperidylene; where the hetero atom is unsubstituted or substituted by a substituent selected from the group consisting of $C(O)OR_{s1}$, $C(O)R_{s2}$, $C(O)NR_8R_9$, NH_2, SO_3M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, sul-

fonhydrazide; and one or more C atoms of the ring are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $OC(O)R_{s4}$, NH_2, OSO_3M_y $NR_{20}SO_3M_y$, C_1-C_{12}alkoxy, C_6-C_{10}aryloxy, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyloxy, primary amino, secondary amino, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_8 and R_9 are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_6-C_{15}heteroaralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, or R_8 and R_9 together are tetramethylene, pentamethylene, $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_2-S-(CH_2)_2-$ or $-(CH_2)_2-NR_7-(CH_2)_2-$, and R_7 is H, C_1-C_6alkyl, C_7-C_{11}aralkyl, $C(O)R_{s2}$ or sulfonyl; and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Particularly preferred compounds are those in which R_5 and R_6 are, together with the -CH-CH- group, piperidylene; where the hetero atom is unsubstituted or substituted by a substituent selected from the group consisting of $C(O)OR_{s1}$, $C(O)R_{s2}$, $-C(O)NR_8R_9$ and $R_{10}-SO_2-$ and one or more C atoms of the ring are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, NH_2, $R_8S(O)_2N(R_9)-$; $R_8C(O)N(R_9)-$ and $R_8OC(O)N(R_9)-$, where R_9 is hydrogen and R_8 is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, where alkyl, aryl and aralkyl are unsubstituted or substituted by one or more C_1-C_{12}alkoxy; R_{10} is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more C_1-C_{12}alkyl; R_{s1} is C_1-C_{12}alkyl and R_{s2} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkenyl, C_3-C_{12}cycloalkyl or C_6-C_{10}aryl, and alkyl, cycloalkenyl, cycloalkyl and aryl as substituents in turn are unsubstituted or substituted by one or more substituents selected from the

group consisting of OH, $C(O)OR_{s1'}$ and $OC(O)R_{s4'}$ where $R_{s1'}$ is M_y or C_1-C_{12}alkyl and $R_{s4'}$ is C_1-C_{12}alkyl; y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Another subgroup of preferred compounds are those compounds in which R_5 and R_6 are, together with the -CH-CH- group, piperidylene; which is unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, NH_2, C_1-C_{12}alkyl, $R_8C(O)N(R_9)$-, $-C(O)NR_8R_9$, $R_8S(O)_2N(R_9)$-; $R_8OC(O)N(R_9)$-, $R_8R_{40}NC(O)N(R_9)$-, $-OC(O)NR_8R_9$ and R_{10}-SO_2-, in which R_9 is hydrogen and R_8 is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, where alkyl, aryl and aralkyl are unsubstituted or substituted by one or more C_1-C_{12}alkoxy or C_7-C_{11}aralkyloxy; R_{10} is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more C_1-C_{12}alkyl; R_{40} is hydrogen, OH, C_1-C_{12}alkyl, C_1-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, C_6-C_{15}heteroaralkyl, C_6-C_{15}heteroaralkenyl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, R_{s1} and R_{s4} are C_1-C_{12}alkyl and R_{s2} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkenyl, C_3-C_{12}cycloalkyl or C_6-C_{10}aryl, and alkyl, cycloalkenyl, cycloalkyl and aryl as substituents in turn are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1'}$ and $OC(O)R_{s4'}$ where $R_{s1'}$ is M_y or C_1-C_{12}alkyl and $R_{s4'}$ is C_1-C_{12}alkyl; y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

Very particularly preferred compounds of the formula I are those in which X is cyclohexylene or piperidylene which is unsubstituted or substituted by one or more substituents selected from the group consisting of OH, NH_2, C_3H_7, $-C(O)CH_3$, $-C(O)C_6H_5$, $-C(O)(CH_2)_8C(O)OCH_3$, $-C(O)[CH(OH)]_2C(O)ONa$, $C(O)$-$C_6H_8(OH)_3$, $-C(O)$-C_6H_{11}, $-C(O)OC_3H_7$, $-C(O)NHC_6H_5$, $-NHS(O)_2CH_2C_6H_5$, $-NHC(O)OCH_2C_6H_5$, $-NHC(O)C_6H_3(OCH_3)_2$, $-S(O)_2$-C_4H_9, $-NHC(O)NHC_6H_5$, $-S(O)_2$-$C_6H_4CH_3$, $-S(O)_2$-$CH_2C_6H_5$ and $-S(O)_2$-$(CH)_2C_{10}H_7$.

Preferred compounds of the formula I are those in which R_1 corresponds to a group of the formula III in which R_3 is hydrogen or M_y and R_4 is
(a) unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of $-NH_2$, primary amino, secondary amino, C_1-C_{12}sulfonyl, carbamide, carbamate, carbhydrazide, sulfonamide, sulfonhydrazide, aminocarbonylamido, C_3-C_{12}cycloalkyl, C_1-C_6alkoxy, phenyloxy and benzyloxy; unsubstituted

C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more substituents selected from the group consisting of C_3-C_{12}cycloalkyl, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_{12}sulfonyl, phenyloxy and benzyloxy; C_6-C_{10}aryl; C_3-C_9heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms; C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; C_4-C_{16}heteroaralkyl with C_1-C_6alkyl and C_3-C_{10}heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms and a total of 3 to 5 carbon atoms; C_6-C_{10}aryl, C_3-C_9heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms, C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, C_3-C_{16}heteroaralkyl with C_1-C_6alkyl and C_4-C_{10}heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms and a total of 3 to 5 carbon atoms, which are substituted by one or more substituents selected from the group consisting of OH, halogen, C_1-C_{12}sulfonyl, carboxyl, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and nitro, NH_2, primary amino, secondary amino, carbamide, carbamate, sulfonamide and cyano, in which y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal, or

(b) C_1-C_{12}alkyl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl

and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

R_3 in formula III is preferably hydrogen, K or Na.

The following preferences apply to the group (a) of meanings for R_4:

R_4 is alkyl, preferably methyl, ethyl, n- or i-propyl and n-, i- or t-butyl. In the case of substituted alkyl, the alkylene group is preferably ethylene and particularly methylene. A particularly preferred cycloalkyl group is cyclohexyl. Preferred as aryl and aralkyl are naphthyl and phenyl, particularly preferably phenyl and phenyl-C_nH_{2n}- with n equal to a number from 1 to 6, in particular benzyl and 2-phenylethyl. When R_4 is heteroaryl, it is preferably C_4-C_5heteroaryl with one or two hetero atoms from the group of O and N. Furanyl, pyridinyl and pyrimidinyl are preferred. R_4 as heteroaralkyl is preferably C_4-C_5heteroarylmethyl with one or two hetero atoms from the group of O and N, it being possible for heteraryl to comprise the abovementioned heteroaryl groups.

Further preferred compounds are those in which R_4 in formula III is a C_3-C_{12}cycloalkyl, particularly preferably cyclohexyl, C_1-C_4alkyl substituted, particularly methyl or ethyl, with C_3-C_{12}cycloalkyl or with C_1-C_4alkyl and particularly with cyclohexyl or methyl, C_6-C_{10}aryl and very particularly phenyl, or R_4 is a C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl. Particularly preferred groups for R_4 in this series are benzyl, naphthylmethyl, 2-phenylethyl, 3-phenylpropyl, cyclohexylmethyl, 2-cyclohexylethyl, cyclohexyl and isopropyl.

Carbamido, carbhydrazido, sulfonamido, sulfonhydrazido, aminocarbonylamide and carbamate as substituent for R_4 preferably mean groups of the formulae $R_8NHC(O)N(R_9)$-, $R_8OC(O)N(R_9)$-, $R_8C(O)(NH)_pN(R_9)$- and $R_8S(O)_2(NH)_pN(R_9)$-, in which R_8 is preferably H, C_1-C_{12}alkyl, C_5- or C_6cycloalkyl, C_5- or C_6cycloalkylmethyl or -ethyl-, C_5- or C_6heterocycloalkyl, C_5- or C_6heterocycloalkylmethyl or -ethyl-, phenyl, naphthyl, benzyl, 2-phenylethyl, diphenylmethyl, which are unsubstituted or substituted by one or more substituents from the group of -OH, $-NH_2$, C_1-C_8primary amino, C_2-C_{14}secondary amino, NO_2, -CN, -F, -Cl, -C(O)OH, -C(O)ONa, $-SO_3H$, $-OSO_3Na$, $NR_{20}SO_3Na$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl

or C_7-C_{10}heteroaralkenyl, and -SO_3Na, C_1-C_4alkyl, C_1-C_4alkoxy and phenyl, and R_9 is H, C_1-C_{10}alkyl, phenyl, naphthyl, benzyl, 2-phenylethyl or phenyl-CH=CH-CH_2-, and p is 0 or 1.

Within group (a), a carbamido-substituted alkyl substituent for R_4 particularly preferably means R_8-C(O)NR_9-$(CH_2)_n$-, where n is 1 or 2, R_8 is hydrogen; C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl; C_6-C_{10}aryl or C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; wherein alkyl, cycloalkyl, aryl and aralkyl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, -C(O)OM_y, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C(O)OR_{s1}, OC(O)R_{s4}, nitro, amino and cyano; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl or di-C_6-C_{10}aryl-C_1-C_6alkyl; and R_9 is H, linear or branched C_1-C_{10}alkyl, C_5- or C_6cycloalkyl, C_5- or C_6cycloalkylmethyl- or -ethyl, phenyl, naphthyl or benzyl, 2-phenylethyl or phenyl-CH=CH-CH_2-; y is 1 and M is an alkali metal or y is 1/2 and M is an alkaline earth metal, R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl. A sulfonamide-substituted alkyl substituent for R_1 particularly preferably means R_8-SO_2NR_9-$(CH_2)_n$- in which R_8, R_9 and n have the meanings indicated previously for carbamido. An aminocarbonylamide- or carbamate-substituted alkyl substituent for R_1 particularly preferably means R_9NHC(O)NH$(CH_2)_n$ or R_9OC(O)NH$(CH_2)_n$ in which R_9 has the meanings indicated in previously in connection with carbamido and additionally phenyl and n has the meanings indicated previously in connection with carbamido. A carbhydrazido-substituted alkyl substituent for R_1 particularly preferably means R_8C(O)NHN$R_9(CH_2)_n$- in which R_8, R_9 and n have the meanings indicated previously in connection with carbamido. A sulfonhydrazido-substituted alkyl substituent for R_4 particularly preferably means R_8-SO_2-NHNR_9-$(CH_2)_n$- in which R_8, R_9 and n have the meanings indicated previously in connection with carbamido.

Further particularly preferred compounds are those in which R_4 in formula III is an amide $R_8C(O)N(R_9)(CH_2)_n$- or $R_8S(O)_2N(R_9)(CH_2)_n$-; where R_8 and R_9 are, independently of one another, hydrogen; unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, C(O)ONa,

C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, -SO_3H, OSO_3Na, $NR_{20}SO_3Na$, SO_3Na, nitro and cyano; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl substituted by one or more OH; unsubstituted C_6-C_{10}aryl, unsubstituted C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; C_6-C_{10}aryl, or C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, which is substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, C(O)ONa, -C(O)OK, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$, $C(O)OR_{s1}$, $OC(O)R_{s4}$, nitro, amino and cyano, R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; and n is 2 or 1.

Particularly preferred compounds are those in which R_4 in formula III is an amide $R_8C(O)N(R_9)(CH_2)_n$- or $R_8S(O)_2N(R_9)(CH_2)_n$-, where R_8 is unsubstituted C_1-C_{12}alkyl; C_1-C_8alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)ONa and C_6-C_{10}aryl; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_8cycloalkyl which is substituted by one or more OH; unsubstituted C_6-C_{10}aryl or C_7-C_{12}aralkyl with C_1-C_6alkyl; C_6-C_{10}aryl, C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, which is substituted by one or more substituents selected from the group consisting of halogen, -C(O)OH, C(O)ONa, C_1-C_{12}alkyl, C_1-C_6alkoxy, -SO_3H, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and nitro and cyano; and R_9 is hydrogen; unsubstituted C_1-C_6alkyl, unsubstituted C_6-C_{10}aryl, unsubstituted C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, and n is 2 and preferably 1.

Particularly preferred compounds are also those in which R_4 in formula III is an amide $R_8C(O)N(R_9)(CH_2)_n$-, where R_8 is unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of cyclohexyl, OH, halogen, -C(O)OH, -C(O)ONa and phenyl; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more OH; unsubstituted C_6-C_{10}aryl; C_6-C_{10}aryl, which is substituted by

one or more substituents selected from the group consisting of halogen, C(O)ONa, -C(O)OH, C_1-C_6alkyl, C_1-C_6alkoxy, phenyl, -SO_3H, SO_3Na, OSO_3Na, $NHSO_3Na$, nitro and cyano; or C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, and R_9 is hydrogen; unsubstituted C_1-C_6alkyl, unsubstituted C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, and n is 2 and preferably 1.

Further particularly preferred compounds are those in which R_4 in formula III is an amide $R_8C(O)N(R_9)(CH_2)_n$-, where R_8 is unsubstituted C_1-C_{12}alkyl, C_1-C_4alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)OH, C(O)ONa and phenyl; unsubstituted C_3-C_{12}cycloalkyl, in particular C_6H_{11}; C_3-C_{12}cycloalkyl which is substituted by one or more OH, unsubstituted C_6-C_{10}aryl, in particular C_6H_5 or $C_{10}H_7$; C_6-C_{10}aryl which is substituted by one or more substituents selected from the group consisting of halogen, -C(O)OH, C(O)ONa, C_1-C_6alkyl, C_1-C_6alkoxy, -SO_3H, SO_3Na, OSO_3Na, $NHSO_3Na$, nitro and cyano, in particular C_6H_4Cl, $C_6H_4(3,4)Cl_2$, C_6H_4COONa, $C_6H_4CH_3$, $C_6H_4OCH_3$, $C_6H_4SO_3Na$, $C_6H_4NO_2$ or C_6H_4CN; or unsubstituted C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, in particular $(CH_2)_2C_6H_5$, and R_9 is H, C_1-C_4alkyl, phenyl-CH_2-, phenyl-CH_2CH_2, phenyl-$(CH_2)_3$- or phenyl-CH=CH-CH_2-, and n is 2 and preferably 1.

Particularly preferred compounds are also those in which R_4 in formula III is an amide $R_8C(O)N(R_9)(CH_2)_n$-, where R_8 is unsubstituted or substituted C_1-C_{12}alkyl, cyclohexyl, naphthyl, biphenylyl, phenyl, benzyl, phenylethyl or diphenylmethyl, and R_9 is C_1-C_4alkyl, phenyl-C_1-C_6alkyl, in particular $CH_2C_6H_5$, $(CH_2)_2C_6H_5$ or $(CH_2)_3C_6H_5$; or phenyl-C_2-C_6-alkenyl, in particular C_6H_5-CH=CH-CH_2, and n is 2 and preferably 1.

Further particularly preferred compounds are those in which R_4 in formula III is a sulfonamido $R_8S(O)_2N(R_9)(CH_2)_n$-, where R_8 is C_1-C_{12}alkyl, particularly C_1-C_6alkyl, which is unsubstituted or substituted by one or more halogen atoms (for example Cl and especially F), in particular CF_3; or C_6-C_{10}aryl, particularly phenyl or naphthyl, which is substituted by one or more C_1-C_4alkyl (for example methyl or ethyl), C_1-C_4alkoxy (for example methoxy or ethoxy), halogen, -CN or -NO_2, and R_9 is hydrogen or isobutyl, and n is 2 and preferably 1.

Further particularly preferred compounds are those in which R_4 in formula III is an aminocarbonyl residue of the formula R_8-NH-C(O)-$NH(CH_2)_n$-, in which R_8 is C_1-C_{12}alkyl or C_6-C_{10}aryl, particularly C_1-C_6alkyl, which is unsubstituted or substituted by halogen, -CN,

$-NO_2$, C_1-C_4alkyl or C_1-C_4alkoxy, or C_5- or C_6cycloalkyl, C_6-C_{10}aryl such as phenyl or naphthyl, or C_7-C_{12}aralkyl such as benzyl, phenylethyl, phenylpropyl or phenylpropenyl, and n is 2 and preferably 1.

Particularly preferred compounds are furthermore those in which R_4 in formula II is an aminoalkyl, preferably $R_{8'}R_{9'}N(CH_2)_n$-, where $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen; unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)NR_{11}R_{12}$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, $-SO_3H$, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$, nitro, amino and cyano; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more OH; C_6-C_{10}aryl; C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, where aryl and the aryl in the aralkyl and aralkenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, -C(O)ONa, -C(O)OK, $-C(O)-NR_{11}R_{12}$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, $-SO_3H$, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$, nitro, amino and cyano; wherein n is 2 and preferably 1, and R_{s1} is hydrogen, K or Na, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{11} is H, C_1-C_4alkyl, C_2-C_4hydroxyalkyl, phenyl or benzyl, and R_{12} independently has the meaning of R_{11}, or R_{11} and R_{12} together are tetramethylene, pentamethylene or $-CH_2CH_2-O-CH_2CH_2$- and R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl.

Particularly preferred compounds are furthermore those in which R_4 in formula III is an aminoalkyl $R_{8'}R_{9'}NCH_2$-, in which $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen; C_1-C_8alkyl, cyclopentyl, cyclohexyl, C_5- or C_6cycloalkylmethyl, phenyl-C_1-C_4alkyl, in particular $-CH_2C_6H_5$; or phenyl-C_2-C_4alkenyl, in particular $-CH_2CH=CHC_6H_5$.

Particularly preferred compounds are furthermore those in which R_4 in formula III is an amine $R_{8'}R_{9'}NCH_2$-, where $R_{8'}$ and $R_{9'}$ are, independently of one another, H, C_1-C_6alkyl, phenyl-C_1- or C_2alkyl, in particular $CH_2C_6H_5$.

Preferred compounds of group (b) of meanings for R_4, are those in which R_4 is C_7-C_{11}aralkyl, in particular CH_2-C_6H_5 and $(CH_2)_2$-C_6H_5, C_3-C_{12}cycloalkyl or C_1-C_{12}alkyl, which is unsubstituted or substituted by one or more substituents selected from the group consisting of NH_2, C_3-C_{12}cycloalkyl, primary amino, secondary amino, sulfonamide, carbamide and aminocarbonylamido. Particularly preferred substituents for C_1-C_{12}alkyl are NH_2, cyclohexyl, C_6-C_{10}aryl, $R_8C(O)N(R_9)$-, $R_8S(O)_2N(R_9)$-, $R_8NHC(O)NR_9$-, $NR_9C(O)NHR_8$ and R_8R_9N-, in which R_8 and R_9 are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11} aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; p is 0 or 1 and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal; or $R_{8'}$ and $R_{9'}$ together are tetramethylene, pentamethylene, $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_2-S-(CH_2)_2-$ or $-(CH_2)_2-NR_7-(CH_2)_2-$, and R_7 is H, C_1-C_6alkyl, C_7-C_{11}aralkyl, $C(O)R_{s2}$ or sulfonyl.

Particularly preferred compounds within this group are those in which R_4 is CH_2-C_6H_5, $(CH_2)_2$-C_6H_5, cyclohexyl, methyl, ethyl or isopropyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of NH_2, cyclohexyl, C_6-C_{10}aryl,

$R_8C(O)N(R_9)$-, $R_8S(O)_2N(R_9)$-, $R_8NHC(O)NR_9$-, $NR_9C(O)NHR_8$ and R_8R_9N-, in which R_8, R_9, $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OM_y$, nitro, cyano, SO_3M_y, OSO_3M_y, $NHSO_3M_y$, C_1-C_{12}alkyl, C_1-C_{12}alkoxy and C_6-C_{10}aryl, where y is 1 and M is a monovalent metall or y is 1/2 and M is a divalent metal. Particularly preferred compounds are those in which R_8, R_9, $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, C_1-C_{12}alkyl, cyclohexyl, phenyl, naphthyl or C_7-C_{11}aralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, F, Cl, C(O)ONa, nitro, cyano, SO_3Na, C_1-C_6alkyl, methoxy and phenyl.

In a preferred group of compounds of the formula I, R_1 is formula III, in which R_4 is C_6H_{11}, $CH(CH_3)_2$, CH_2-phenyl, $(CH_2)_2$-phenyl, $CH_2NHC(O)$-phenyl, $CH_2NHC(O)(CH_2)_3$-phenyl, $CH_2NHC(O)(CH_2)_3OH$, $CH_2NHC(O)CF_3$, $CH_2NHC(O)C_6H_{11}$, $CH_2NHC(O)C_{11}H_{23}$, $CH_2NHC(O)CH(C_6H_5)_2$, $CH_2HNC(O)NHC_6H_5$, $CH_2NHC(O)C_2H_4CO_2Na$, $CH_2NHC(O)C_6[(1,3,4,5)OH]_4H_7$, $CH_2NHC(O)C_6H_4$-p-SO_3Na, $CH_2NHC(O)C_6H_4Cl$, $CH_2NHC(O)C_6H_4NO_2$, $CH_2NHC(O)C_6H_4OCH_3$, $CH_2NHC(O)C_6H_4(3,4)Cl_2$, $CH_2NHC(O)C_6H_4CH_3$, $CH_2NHC(O)C_6H_4C_6H_5$, $CH_2NHC(O)C_6H_4CN$, $CH_2NHC(O)C_{10}H_7$, $CH_2NHC(O)C_6H_4COONa$, $CH_2NHC(O)(CHOH)_2COONa$, $CH_2N(CH_2CH=CH\text{-phenyl})[C(O)\text{-phenyl}]$, $CH_2N[CH_2CH(CH_3)_2][C(O)\text{-phenyl}]$, $CH_2N[C(O)C_6H_5]CH_2C_6H_5$, $CH_2N[C(O)C_6H_5](CH_2)_3C_6H_5$, $CH_2C_6H_{11}$, $(CH_2)_2C_6H_{11}$, CH_2NH_2, $CH_2NHCH_2CH=CH$-phenyl, CH_2NHCH_2-phenyl, $CH_2NHCH_2CH(CH_3)_2$, $CH_2N(CH_2\text{-phenyl})_2$, $CH_2N[CH_2CH(CH_3)_2]_2$, CH_2NHSO_2-p-nitrophenyl, CH_2NHSO_2-p-tolyl, $CH_2NHSO_2CF_3$, $CH_2NHC(O)NHC_6H_5$ or $CH_2N[SO_2\text{-p-nitrophenyl}][CH_2CH(CH_3)_2]_2$.

R_2 as alkyl can contain preferably from 1 to 6 C atoms and particularly preferably from 1 to 4 C atoms. Methyl and ethyl are particularly preferred.

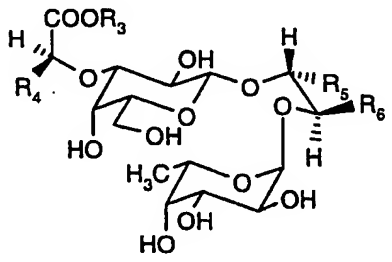
In the case of halogen for the substituents for R_2, it can preferably be F, Cl and Br; in the case of $-C(O)OM_y$ preferably -C(O)ONa or -C(O)OK; in the case of alkyl preferably C_1-C_6- and particularly preferably C_1-C_4alkyl, such as methyl, ethyl, n- or i-propyl and n-, i- or t-butyl; in the case of alkoxy preferably C_1-C_4alkoxy, for example methoxy and ethoxy; in the case of aryl preferably phenyl or naphthyl; in the case of $-SO_3M_y$ preferably $-SO_3Na$ or $-SO_3K$; in the case of primary amino C_1-C_{12}primary amino such as methyl-, ethyl-, n- or

i-propyl-, n-, i- or t-butyl, pentyl, hexyl, cyclohexyl, phenyl or benzylamino; in the case of secondary amino C_2-C_{20}secondary amino such as dimethyl-, diethyl-, methylethyl-, di-n-propyl-, di-i-propyl-, di-n-butyl-, diphenyl-, dibenzylamino, morpholino, thiomorpholino, piperidino and pyrrolidino; -SO_2-NR_8R_9; and -C(O)-NR_8R_9 in which R_8 and R_9 are, independently of one another, H, C_1-C_4alkyl, C_2-C_4hydroxyalkyl, phenyl or benzyl, or R_8 and R_9 together with the N atom are morpholino, thiomorpholino, pyrrolidino or piperidino.

R_8 and R_9 as alkyl preferably contain 1 to 6, and particularly preferably 1 to 4, C atoms, and can be, for example, methyl, ethyl, n- or i-propyl or n-, i- or t-butyl. R_8 and R_9 as hydroxyalkyl preferably contain 1 to 6, and particularly preferably 1 to 4, C atoms, and can be, for example, hydroxymethyl or 2-hydroxyethyl. R_8 and R_9 as cycloalkyl are preferably cyclopentyl or cyclohexyl. Substituents for R_8 and R_9 as phenyl and benzyl are preferably F, Cl, methyl, ethyl, methoxy and ethoxy.

A preferred subgroup of compounds of the formula I are those in which R_2 is hydrogen, unsubstituted C_1-C_6alkyl, particularly preferably C_1-C_4alkyl, especially methyl or ethyl, or C_1-C_6alkyl, particularly preferably C_1-C_4alkyl, especially methyl or ethyl, which is substituted by C(O)OH, -C(O)ONa, -C(O)OK, -OH, -C(O)-NR_8R_9 or -SO_2-NR_8R_9, in which R_8 is H, C_1-C_4alkyl, C_2-C_4hydroxyalkyl, phenyl or benzyl, and R_9 independently has the meaning of R_8, or R_8 and R_9 are together tetramethylene, pentamethylene or -CH_2CH_2-O-CH_2CH_2-. Particularly preferred compounds are those in which R_2 is hydrogen, methyl, ethyl, HO(O)CCH_2CH_2-, NaOC(O)CH_2CH_2- or R_8R_9NC(O)CH_2CH_2-, and R_8 and R_9 are, independently of one another, H, C_1-C_6alkyl, C_2-C_4hydroxyalkyl, phenyl, benzyl or, together, morpholino.

A particularly preferred embodiment of the invention comprises compounds of the formula Ia



(Ia)

in which

R_3 is hydrogen or M_y; and

R_4 is C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl or C_7-C_{10}heteroaralkenyl, which are unsubstituted or substituted once or several times;

R_5 and R_6 are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; or R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_4-C_{12}cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group of -O-, -S- and -N-;

where alkyl, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkylene, cycloalkenylene, heterocycloalkylene and heterocycloalkenylene are unsubstituted or substituted once or several times;

where the substituent is selected from the group OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9hetero-aryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are substituted or unsubstituted by one of the abovementioned substituents; and

y is 1 and M is a monovalent metal or y is a 1/2 and M is a divalent metal.

Preferred compounds of the formula Ia are those in which
R_3 is H, K or Na,
R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_4-C_{12}cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group -O-, -S- and -N-; which are unsubstituted or substituted once or several times;
where the substituent is selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, in which R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and
y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal;
(a) R_4 is a residue R_{12}-$(CH_2)_n$- or cyclohexyl, in which n is 1 or 2 and
R_{12} is C_1-C_{10}alkyl, C_5-C_8cycloalkyl, especially cyclohexyl, C_6-C_{10}aryl, preferably phenyl, or C_8-C_{12}aralkenyl, preferably phenyl-C_2-C_4alkenyl, which are unsubstituted or substituted by C_1-C_4alkyl, C_1-C_4alkoxy, F, Cl, -CN or $-NO_2$; or

R_{12} is an amino group $-NR_{8'}R_{9'}$, and $R_{8'}$ and $R_{9'}$ are C_1-C_{12}alkyl or unsubstituted or C_1-C_4alkyl-substituted C_5- or C_6cycloalkyl, C_6-C_{10}aryl, C_7-C_{12}aralkyl or C_8-C_{12}aralkenyl; very particularly preferably $-CH_2-CH(CH_3)_2$, $-CH_2-C(CH_3)_3$, $-CH_2-C(CH_3)_2-C_2H_5$, $C_6H_5-CH_2-$, $C_6H_5CH_2CH_2-$, $C_6H_5-CH_2-CH_2-CH_2-$ or $C_6H_5CH=CH-CH_2-$, or

R_{12} is an amide group $-N(R_9)C(O)R_8$, $-N(R_9)S(O)_2R_8$, $-NR_9C(O)NHR_8$ or $-NR_9C(O)NHR_8$ in which R_8 is C_6-C_{10}aryl, preferably phenyl, which is unsubstituted or substituted by C_1-C_4alkyl, especially methyl, C_1-C_4alkoxy, especially methoxy, F, Cl, -CN or $-NO_2$, or C_1-C_{10}alkyl which is unsubstituted or substituted by F or Cl, and R_9 is H, C_1-C_{10}alkyl, C_5- or C_6cycloalkyl, C_5- or C_6cycloalkyl-C_1-C_6alkyl, phenyl-C_1-C_6alkyl or phenyl-C_2-C_6alkenyl, especially H, C_1-C_6alkyl, cyclohexyl, cyclohexyl-CH_2-, cyclohexyl-CH_2CH_2-, cyclohexyl-$CH_2CH_2CH_2$-, $C_6H_5CH_2$, $C_6H_5CH_2CH_2$-, $C_6H_5CH_2CH_2CH_2$- and $C_6H_5CHCHCH_2$-, R_9 is particularly H, linear and, preferably, branched C_1-C_6alkyl, phenyl or phenyl$(CH_2)_z$- with z equal to a number from 1 to 4, for example methyl, ethyl, n- or i-propyl, n-, i- or t-butyl, pentyl, isopentyl, hexyl, benzyl, phenylethyl, phenylpropyl and phenyl-CH=CH-CH_2-, very particularly preferably $CH_2-CH(CH_3)_2$, benzyl, 2-phenylethyl and 3-phenylpropyl; or

(b) R_4 is C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroar-

alkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and

y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

A preferred subgroup of compounds of group (a) are those in which

(i) R_4 is C_6H_{11}, C_6H_{11}-CH_2, C_6H_{11}-CH_2CH_2-, C_6H_5-CH_2-, C_6H_5-CH_2CH_2- or C_6H_5-CH=CH-CH_2-;

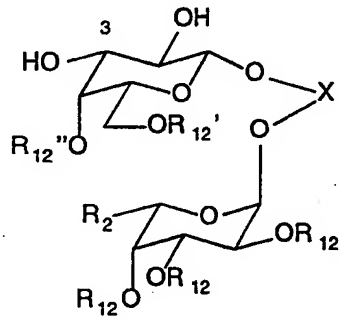
(ii) R_4 is C_6H_{11}, C_6H_{11}-CH_2-, C_6H_{11}-CH_2CH_2-, C_6H_5-CH_2-, C_6H_5-CH_2CH_2-, -CH_2-NR_{19}-SO_2R_{18}, -CH_2-NR_{19}-$C(O)R_{40}$, $CH_2NHC(O)NHR_{18}$, -CH_2NHR_{21} or $CH_2N(R_{21})_2$, in which R_{18} is -C_6H_5, phenyl which is substituted by 1 to 3 methyl or methoxy or -NO_2 or F or Cl, in particular p-CH_3-C_6H_4-, p-CH_3O-C_6H_4- or 2,3,5,-CH_3-C_6H_2- or p-O_2N-C_6H_4-, or C_1-C_4alkyl, which is substituted by F, in particular -CF_3; R_{40} is phenyl which is unsubstituted or substituted by 1 to 3 methyl or methoxy or -NO_2 or F or Cl; R_{19} is H, C_1-C_6alkyl, phenyl-$(CH_2)_z$- with z equal to a number from 1 to 3, phenyl-CH=CH-CH_2-, and especially -CH_2-$CH(CH_3)_2$ or benzyl; and R_{21} is -CH_2-$CR_{22}R_{23}R_{24}$ in which R_{22} and R_{23}, methyl, ethyl or phenyl and R_{24} is H, ethyl or methyl, very particularly preferably R_{22} and R_{23} are methyl and R_{24} is H.

A preferred subgroup of the compounds of group (b) are those in which R_4 is C_6H_{11}, CH_2-C_6H_5, $(CH_2)_2$-C_6H_5, methyl, ethyl or isopropyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of NH_2, cyclohexyl, C_6-C_{10}aryl, $R_8C(O)N(R_9)$-, $R_8S(O)_2N(R_9)$-, $NR_9C(O)NHR_8$ and R_8R_9N- in which R_8, R_9, $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OM_y$, nitro, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and C_1-C_{12}alkyl, C_1-C_{12}alkoxy and C_6-C_{10}aryl, where y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal. Particularly preferred compounds are those in which R_8, R_9, $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, C_1-C_{12}alkyl, cyclohexyl, phenyl, naphthyl or C_7-C_{11}aralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, F, Cl, C(O)ONa, nitro, cyano, SO_3Na, C_1-C_6alkyl, methoxy and phenyl.

In a preferred group of compounds of the formula Ia, R_4 is C_6H_{11}, $CH(CH_3)_2$, CH_2-phenyl, $(CH_2)_2$-phenyl, $CH_2NHC(O)$-phenyl, $CH_2NHC(O)(CH_2)_3$-phenyl, $CH_2NHC(O)(CH_2)_3OH$,

$CH_2NHC(O)CF_3$, $CH_2NHC(O)C_6H_{11}$, $CH_2NHC(O)C_{11}H_{23}$, $CH_2NHC(O)CH(C_6H_5)_2$, $CH_2HNC(O)NHC_6H_5$, $CH_2NHC(O)C_2H_4CO_2Na$, $CH_2NHC(O)C_6[(1,3,4,5)OH]_4H_7$, $CH_2NHC(O)C_6H_4$-p-SO_3Na, $CH_2NHC(O)C_6H_4Cl$, $CH_2NHC(O)C_6H_4NO_2$, $CH_2NHC(O)C_6H_4OCH_3$, $CH_2NHC(O)C_6H_4(3,4)Cl_2$, $CH_2NHC(O)C_6H_4CH_3$, $CH_2NHC(O)C_6H_4C_6H_5$, $CH_2NHC(O)C_6H_4CN$, $CH_2NHC(O)C_{10}H_7$, $CH_2NHC(O)C_6H_4COONa$, $CH_2NHC(O)(CHOH)_2COONa$, $CH_2N(CH_2CH=CH\text{-phenyl})[C(O)\text{-phenyl}]$, $CH_2N[CH_2CH(CH_3)_2][C(O)\text{-phenyl}]$, $CH_2N[C(O)C_6H_5]CH_2C_6H_5$, $CH_2N[C(O)C_6H_5](CH_2)_3C_6H_5$, $CH_2C_6H_{11}$, $(CH_2)_2C_6H_{11}$, CH_2NH_2, $CH_2NHCH_2CH=CH$-phenyl, CH_2NHCH_2-phenyl, $CH_2NHCH_2CH(CH_3)_2$, $CH_2N(CH_2\text{-phenyl})_2$, $CH_2N[CH_2CH(CH_3)_2]_2$, CH_2NHSO_2-p-nitrophenyl, CH_2NHSO_2-p-tolyl, $CH_2NHSO_2CF_3$, $CH_2NHC(O)NHC_6H_5$ or $CH_2N[SO_2\text{-p-nitrophenyl}][CH_2CH(CH_3)_2]_2$.

The present invention additionally relates to a process for the preparation of the compounds of the formula I which comprises etherifying the 3-OH group of a compound of the formula V



(V)

in which R_2 and X have the abovementioned meanings, R_{12} is a protective group and R_{12}' and R_{12}" are, independently of one another, hydrogen or a protective group, with a compound of the formula VI

$$R_1\text{-}R_{13} \qquad (VI)$$

in which R_1 has the abovementioned meaning and R_{13} is a leaving group, and eliminating the protective groups.

Leaving groups can be: halides, such as chloride, bromide and iodide, and sulfonic acids, for example trifluoromethanesulfonate, aliphatic, cycloaliphatic or aromatic sulfonic acids which are unsubstituted or substituted by C_1-C_4alkyl; C_1-C_4alkoxy, nitro, cyano or halogen (chlorine, bromine). Some examples of these acids are: methanesulfonic acid, mono-, di- or trifluoromethanesulfonic acids or p-nitrobenzenesulfonic acid. CF_3-SO_2-O^- (also referred to as triflate) is particularly preferably used. The leaving group is advantageously selected from the group consisting of halogen and unsubstituted and halogenated R-SO_2-, in which R is C_1-C_{12}alkyl, in particular C_1-C_6alkyl, C_5-C_6cycloalkyl, phenyl, benzyl, C_1-C_{12}alkylphenyl, in particular C_1-C_4alkylphenyl, or C_1-C_{12}alkylbenzyl, in particular C_1-C_4alkylbenzyl, for example methane, ethane, propane, butane, benzene, benzyl- and p-methylbenzenesulfonyl. Preferred leaving groups are Cl, Br, I, -SO_2CF_3 (triflate) and p-nitrobenzenesulfonyl, and -SO_2CF_3 is particularly preferred.

The compounds of the formula VI are known in some cases or can be obtained by known processes, as described by Degerbeck et al. [Degerbeck, F., Fransson, B., Grehn, L., Ragnarsson, U., J. Chem. Soc. Perkin Trans. 1:11-14 (1993)] and by Dureault et al. [Dureault, A., Tranchepain, I., Depezay, J.C., Synthesis 491-493 (1987)]. Optically pure compounds can be obtained by using optically pure starting compounds (e.g. amino acids, α-hydroxylic acids) or by chromatographic separation processes, for example with chiral solid phases.

The compounds of the formula V are novel and the invention likewise relates to them. They can be obtained by known glycosylation methods starting from known fucosyl and galactosyl donors and diols of the formula HO-X-OH. Stepwise introduction of galactose and fucose or vice versa is advantageous.

For the preparation of the compounds of the formula V, firstly the pseudo-trisaccharide building blocks are synthesized. The pseudotrisaccharide is assembled either by glycosidic attachment for the activated and protected galactose onto the fucose-O-X-OH building block or by glycosidic attachment of suitably protected and activated fucose onto a galactose-O-X-OH building block. Glycosylation reactions are known on a large scale and are described in the specialist literature.

It is then possible to introduce the group R_1 into the pseudotrisaccharide. The resulting compounds of the formula I can subsequently be modified. This modification may comprise hydrogenation of aromatic compounds to cycloaliphatic groups, which can take place, for example, at the same time as the hydrogenolytic elimination of protective groups. It is furthermore possible for an amino group to be acylated and/or alkylated and/or sulfonated. The preparation of secondary and tertiary amines can be carried out by reductive amination.

It has proved advantageous to activate the 3-OH group of the galactose residue by etherification. Particularly suitable for this purpose are dialkyltin oxides, dialkyltin alkoxylates and bis(trialkyl)tin oxides. Some examples are dibutyltin oxide, dibutyltin(O-methyl)$_2$ and (tributyltin)$_2$O. The activating agents are preferably used in stoichiometric amounts. In this case, the reaction is carried out in two stages, namely a) activation and b) coupling with the compounds of the formula VI.

The activation process can be carried out at temperatures from 40 to 200°C, preferably 60 to 120°C.

The compounds of the formula V and of the formula VI can be employed in equimolar amounts. However, it has proved expedient to employ the compounds of the formula VI in excess, for example in an amount which is up to 10 times, preferably up to 5 times, the amount of the compound of the formula V.

It is furthermore expedient to carry out the reaction in both reaction stages in the presence of an inert solvent or mixtures of solvents. Reactive protic solvents such as alkanols and, furthermore, acid amides are unsuitable in reaction stage b). It is possible to use non-polar aprotic and polar aprotic or polar protic solvents. These may be aliphatic or aromatic hydrocarbons such as pentane, hexane, cyclohexane, methylcyclohexane, benzene, toluene or xylene, halogenated hydrocarbons such as methylene chloride, chloroform, tetrachloromethane, 1,2-dichloroethane, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane and chlorobenzene, linear or cyclic ethers such as diethyl ether, dibutyl ether, ethylene glycol dimethyl or diethyl ether, tetrahydrofuran and dioxane, N,N-dialkylated carboxamides such as dimethylformamide, N-alkylated lactams such as N-methylpyrrolidone, ketones such as acetone and methyl isobutyl ketone, carboxylic esters such as methyl or ethyl acetate, or

alkanols such as methanol, ethanol, propanol, butanol and ethylene glycol monoethyl ether. Particularly preferred solvents are methanol, ethanol, benzene and toluene.

Protective groups and processes for derivatizing hydroxyl groups with such protective groups are generally known in sugar and nucleotide chemistry and are described, for example, by Beaucage, S.L. Iyer, R., Tetrahedron 48:2223-2311 (1992). Examples of such protective groups are: benzyl, methylbenzyl, dimethylbenzyl, methoxybenzyl, dimethoxybenzyl, bromobenzyl, 2,4-dichlorobenzyl; diphenylmethyl, di(methylphenyl)methyl, di(dimethylphenyl)methyl, di(methoxyphenyl)methyl, di(dimethoxyphenyl)methyl, triphenylmethyl, tris-4,4',4"-tert-butylphenylmethyl, di-p-anisylphenylmethyl, tri(methylphenyl)methyl, tri(dimethylphenyl)methyl, methoxyphenyl(diphenyl)methyl, di(methoxyphenyl)phenylmethyl, tri(methoxyphenyl)methyl, tri(dimethoxyphenyl)methyl; triphenylsilyl, alkyldiphenylsilyl, dialkylphenylsilyl and trialkylsilyl with 1 to 20, preferably 1 to 12, and particularly preferably 1 to 8 C atoms in the alkyl groups, for example triethylsilyl, tri-n-propylsilyl, i-propyldimethylsilyl, t-butyl-dimethylsilyl, t-butyl-diphenylsilyl, n-octyl-dimethylsilyl, (1,1,2,2-tetramethylethyl)dimethylsilyl; C_2-C_{12}-, in particular C_2-C_8acyl, such as acetyl, propanoyl, butanoyl, pentanoyl, hexanoyl, benzoyl, methylbenzoyl, methoxybenzoyl, chlorobenzoyl and bromobenzoyl. The protective groups can be identical or different. Preferred protective groups are selected from the group consisting of linear and branched C_1-C_8alkyl, in particular C_1-C_4alkyl, for example methyl, ethyl, n- and i-propyl, n-, i- and t-butyl; C_7-C_{12}aralkyl, for example benzyl; trialkylsilyl with 3 to 20 C atoms, in particular 3 to 12 C atoms, for example triethylsilyl, tri-n-propylsilyl, tri-i-propylsilyl, i-propyl-dimethylsilyl, t-butyl-dimethylsilyl, t-butyl-diphenylsilyl, n-octyl-dimethylsilyl, (1,1,2,2-tetramethylethyl)dimethylsilyl; substituted methylidene groups which are obtainable by acetal or ketal formation from adjacent hydroxyl groups of the sugars or sugar derivatives with aldehydes and ketones, which preferably contain 2 to 12 or 3 to 12 C atoms, for example C_1-C_{12}alkylidene, preferably C_1-C_6alkylidene and in particular C_1-C_4alkylidene, such as ethylidene, 1,1- and 2,2-propylidene, 1,1- and 2,2-butylidene, benzylidene; unsubstituted and halogenated C_2-C_{12}acyl, in particular C_2-C_8acyl, such as acetyl, propanoyl, butanoyl, pentanoyl, hexanoyl, pivaloyl and benzoyl.

The synthesis preferably takes place with protective groups for R_{12}' and R_{12}" which together form an alkylidene group with, preferably 1 to 12 and, more preferably 1 to 8 C atoms. In this connection, particularly preferred protective groups are those in which R_{12}' and R_{12}" together are an alkylidene group with, in particular, 1 to 12 C atoms, with the alkylidene group

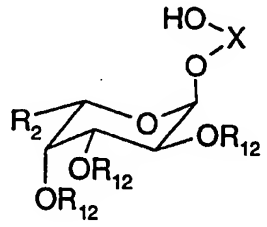
forming an acetal or ketal with the oxygen atoms. These protective groups are ones which can be eliminated under neutral or weakly acidic conditions. Particularly suitable protective groups are acyl, benzyl, substituted benzyl, benzyloxymethyl, alkyl and silyl. R_{12}' and R_{12}" are, particularly preferably, together alkylidene, for example alkyl- or alkoxy- substituted benzylidene. R_{12}' and R_{12}" can, however, also be hydrogen, or one of R_{12}' and R_{12}" can be a protective group such as benzyl and the other one of R_{12}' and R_{12}" can be hydrogen.

Examples of protective carboxylate groups are alkoxy- and aralkoxycarbonyl groups, preferably $-CO_2Bn$, $-CO_2CH_3$.

The reaction for elimination of the protective groups is preferably carried out at a temperature of 0°C to 50°C, and particular at room temperature.

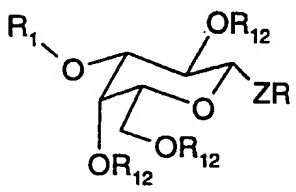
Further details of the preparation of the compounds of the formula I are described in the examples.

An alternative synthetic route comprises glycosidic linkage of the protected fucose hydroxy ether of the formula VII



(VII),

in which R_2, R_{12} and X have the abovementioned meanings, with the protected galactose of the formula VIII



(VIII),

in which R_1 has the abovementioned meaning, Z is O or S, R_{12} is a protective group and R is a leaving group, and subsequent removal of the protective groups from the resulting compound.

It is possible to chose reaction conditions like those implemented for the process described previously. The leaving group R can be, for example, -C(=NH)-CCl_3 or 4-pentenyl. The compounds of the formula VII can be obtained in a simple manner by glycosidic linkage of appropriately protected fucose with a compound of the formula HO-X-OH which is monoprotected where appropriate. The compounds of the formula VIII can be obtained by etherification of compounds of the formula R_1OH with galactose which is protected where appropriate.

The compounds according to the invention have antiinflammatory properties and can accordingly be used as medicaments. It is possible with them in particular to alleviate disorders such as cardiogenic shock, myocardial infarct, thrombosis, rheumatism, psoriasis, dermatitis, acute respiratory distress syndrome, asthma, arthritis and metastatic cancer. The invention furthermore relates to the compounds according to the invention for use in a therapeutic method for the treatment of disorders in warm-blooded animals, including humans. The dosage on administration to warm-blooded animals with a body weight of about 70 kg can be, for example, 0.01 to 1000 mg per day. Administration preferably takes place in the form of pharmaceutical compositions, parenterally, for example intravenously or intraperitoneally.

The invention furthermore relates to a pharmaceutical composition comprising an effective amount of the compound according to the invention, alone or together with other active substances, a pharmaceutical carrier, preferably in a significant amount, and, where appropriate, excipients.

The pharmacologically active compounds according to the invention can be used in the form of compositions which can be administered parenterally or of infusion solutions. Solutions of this type are preferably isotonic aqueous solutions or suspensions, it being possible to prepare the latter, for example in the case of lyophilized compositions which comprise the active substance alone or together with a carrier, for example mannitol, before use. The pharmaceutical compositions can be sterilized and/or comprise excipients, for example pre-

servatives, stabilizers, wetting agents and/or emulsifiers, solubilizers, salts to control the osmotic pressure and/or buffers. The pharmaceutical compositions, which may, if required, comprise other pharmacologically active substances such as antibiotics, are produced in a manner known per se, for example by conventional dissolving or lyophilizing processes, and comprise about 0.1 % to 90 %, in particular from about 0.5 % to about 30 %, for example 1 to 5 %, of active substance(s).

The following examples illustrate the invention.

The following abbreviations are used:

Bz: Benzoyl; Bn: Benzyl; DMTST: Dimethyl(methylthio)sulfonium triflate; FAB: Fast atom bombardment mass spectroscopy; OTf: Triflate; Ph: Phenyl; SEt: C_2H_5S; THG: Thioglycerol; THF: Tetrahydrofuran; NBA: m-Nitrobenzyl alcohol; DMF: N,N-Dimethylformamide; DME: 1,2-Dimethoxyethane; MeOH: Methanol; HRP: Horse radish peroxidase; BSA: Bovine serum albumin; PAA: Polyacryl amide; SA: Streptavidin

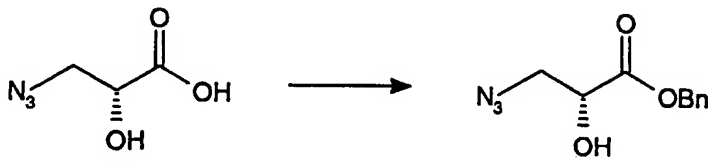
An unconnected hyphen in the formulae means methyl.

Molecular sieves are activated at 300°C under high vacuum for 12 hours before use. They are used in powdered form.

A: Preparation of starting compounds

Example A1: Preparation of compound No. A1

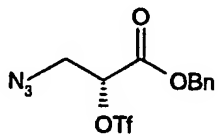
a)



28 **29**

Benzyl chloride (660 ml, 5.72 mmol) is added at room temperature to a mixture of R-3-azido-2-hydroxypropionic acid **28** [Dureault, A., Tranchepain, I., Depezay, J.C., Synthesis 491-493 (1987)], triethylamine (850 ml, 6.1 mmol) and DMF (7.0 ml). The mixture is stirred for 16 hours, and then further triethylamine (850 µl, 6.1 mmol) and benzyl chloride (660 µl, 5.72 mmol) are added. The reaction mixture is stirred for two days and then con-

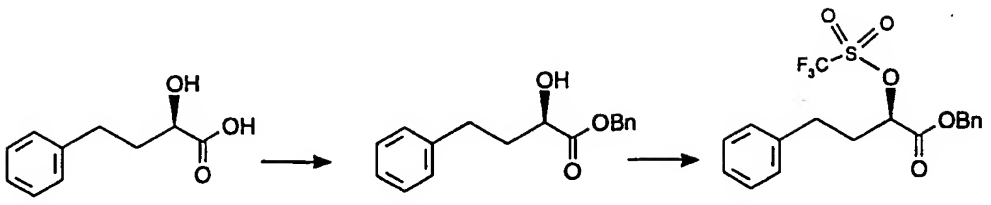
centrated under high vacuum. The residue is taken up in water and the mixture is extracted several times with ethyl acetate. The combined organic phases are washed with saturated NaCl solution, dried (Na_2SO_4), filtered and concentrated in vacuo. The crude product (1 g) is purified by flash chromatography on silica gel (ethyl acetate/hexane 1:4), resulting in benzyl R-3-azido-2-hydroxypropionate **29** (0.717 g, 85 %) as an oil. ^{1}H NMR (250 MHz, $CDCl_3$) δ 7.36 (m, 5H), 5.25 (s, 2H), 4.39 (q, J=4.2 Hz, 1H), 3.65 (dd, J=3.3, 12.9 Hz, 1H), 3.51 (dd, J=4.3, 12.9 Hz, 1H), 3.20 (d, J=4.0 Hz, 1H).

b) **29** 

A1

Trifluoromethanesulfonic anhydride (770 ml, 4.41 mmol) is added at -20°C with stirring to a solution of the alcohol **29** (0.85 g, 3.84 mmol) and 2,6-di-*tert*-butylpyridine (1.12 ml, 4.99 mmol) in dry CH_2Cl_2 (11.0 ml). The clear colourless solution is warmed to 0°C over the course of 40 minutes and is stirred at this temperature for a further 2 hours. The mixture is diluted with CH_2Cl_2 (40 ml) and, while stirring vigorously, 1 M aqueous KH_2PO_4 solution (30 ml) is added. The organic phase is separated off and the aqueous phase is extracted twice with CH_2Cl_2. The combined organic phases are washed with H_2O (30 ml), dried (Na_2SO_4), filtered and concentrated in vacuo. The oily residue (2.3 g) is purified by flash chromatography on a short silica gel column (ethyl acetate/hexane 1:7), resulting in the benzyl *R*-3-azido-2-trifluoromethanesulfonyloxypropionate **A1** (1.16 g, 85 %) as a yellowish oil. ^{1}H NMR (250 MHz, $CDCl_3$) δ 7.38 (br s, 5H), 5.32 (d, J=12,1 Hz, 1H), 5.27 (d, J=12.1 Hz, 1H), 5.24 (dd, J=4.2, 5.5 Hz, 1H), 3.90 - 3.75 (m, 2H); ^{13}C NMR (63 MHz, $CDCl_3$) δ 164.4, 133.9, 129.1, 128.8, 128.6, 120.9, 81.0, 69.0, 51.5.

Example A2: Preparation of compound No. A2

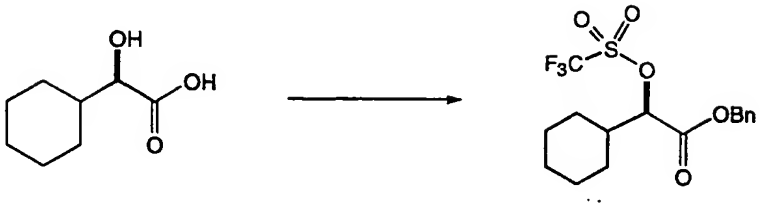


26 27 A2

Benzyl (*R*)-4-phenyl-2-trifluoromethanesulfonyloxybutyrate (**A2**):

A solution of (*R*)-2-hydroxy-4-phenylbutyric acid **26** (0.2 g, 1.11 mmol) in MeOH/ H_2O (9:1, 1.3 ml) is adjusted to pH 8 with 20 % Cs_2CO_3 solution. The solution is concentrated in vacuo and azeotroped first with ethanol and then with hexane, subsequently dried under high vacuum in order to remove remaining H_2O. The residue is mixed with N,N-dimethylformamide (1.3 ml) and benzyl bromide (132 µl, 1.11 mmol) , and the mixture is stirred at room temperature for 75 minutes. Then further benzyl bromide (20 µl, 0.168 mmol) is added, and the mixture is stirred for a further 50 minutes. The white suspension is diluted with CH_2Cl_2 (5 ml), filtered through HyfloSuperCel® and concentrated in vacuo. Purification of the crude product by flash chromatography on silica gel (eluent: ethyl acetate/hexane 4:1) affords benzyl (*R*)- 2-hydroxy-4-phenylbutyrate **27** (0.21 g, 70 %). The product (0.3 g, 1.11 mmol) is dissolved in CH_2Cl_2 (4.5 ml), 2,6-di-*tert*-butylpyridine (323 µl, 1.44 mmol) is added, and the mixture is cooled to -20°C. Then trifluoromethanesulfonic anhydride (222 µl, 1.27 mmol) is added dropwise over the course of 3 minutes, and the solution is warmed to 0°C over the course of 45 minutes. After 75 minutes at 0°C, the mixture is diluted with CH_2Cl_2 (20 ml) and washed with 1 molar aqueous KH_2PO_4 solution (15 ml). The aqueous phase is extracted with CH_2Cl_2 (2 x 10 ml), and the combined organic phases are washed with H_2O (10 ml), dried (Na_2SO_4), filtered and concentrated in vacuo. The residue is purified roughly by column filtration on silica gel (eluent: ethyl acetate/hexane 1:9), resulting in the crude triflate **A2** (0.311 g, 70 %) as an oil. The product is used immediately for the next stage (preparation of **B1.18**). ^1H NMR (250 MHz, $CDCl_3$) δ 7.50 - 7.17 (m, 10H), 5.31 (s, 2H), 5.28 (dd, J=5.5, 11.0 Hz, 1H), 2.82 (m, 2H), 2.41 (m, 2H).

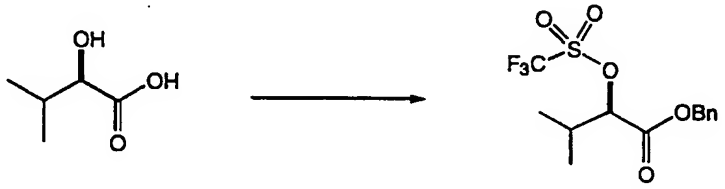
Example A3: Preparation of compound No. A3



(A3)

R-Hydromandelic acid is converted into the triflate **A3** in accordance with Example **A2**.

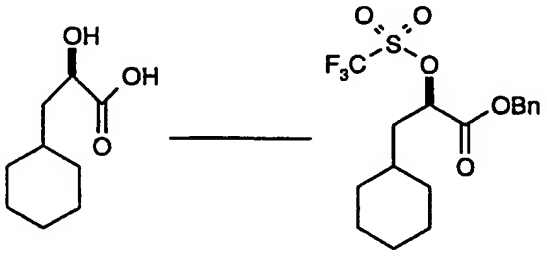
Example **A4**: Preparation of compound No. **A4**



(A4)

R-2-Hydroxy-3-methylbutyric acid is converted into the triflate **A4** in accordance with Example **A2**.

Example **A5**: Preparation of compound No. **A5**

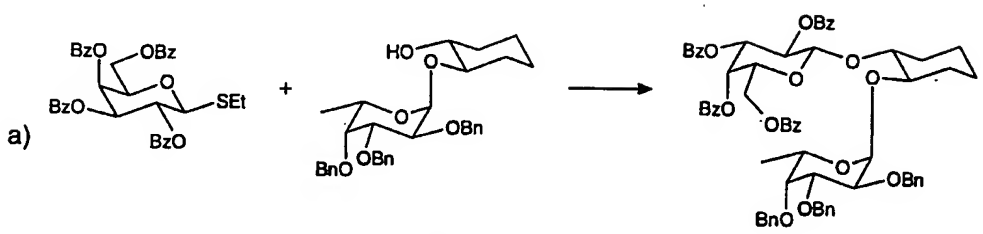


(A5)

R-2-Hydroxy-3-cyclohexylpropionic acid is converted into the triflate **A5** in accordance with Example **A2**.

B Preparation of the mimetics

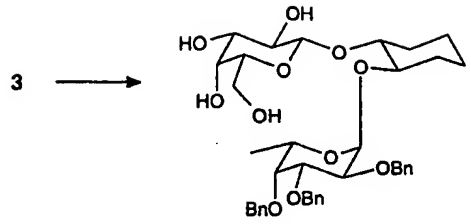
Example B1: Preparation of compound No. B1.1



1 2 3

A mixture of the thioglycoside **1** (5.38 g, 8.40 mmol) [Biessen, E. A. L., Beuting, D.M., Roelen, H.C.P.F., van de Marel, G.A., van Boom, J.H., van Berkel, T.J.C., J. Med. Chem. 38:1538-1546 (1995)] and of the acceptor **2** (3.44 g, 6.46 mmol) is dried under high vacuum for one hour. Then activated 4Å molecular sieves (20 g) and DMTST (4.17 g, 16.14 mmol) are added under a nitrogen atmosphere, followed by CH_2Cl_2 (70 ml). The yellowish suspension is dried at room temperature and, after 3 hours, 5 ml of a suspension consisting of DMTST (5.84 g, 22.61 mmol), 4Å molecular sieves (4.0 g) and CH_2Cl_2 (35 ml) are added. Further 5 ml portions of this DMTST suspension are added after 30, 45 and 90 minutes respectively. The brown reaction mixture is then stirred for 15 hours, and thereafter filtered through Hyflo Super Cel® (filter aid), washing with CH_2Cl_2 (300 ml). The filtrate is extracted by shaking first with 10 % aqueous $NaHCO_3$ solution and then with saturated NaCl solution, and the organic phase is dried with Na_2SO_4, filtered and concentrated in a vacuum rotary evaporator. The remaining brown foam is purified by two column chromatographies on silica gel (eluent for 1st chromatography: ethyl acetate/hexane 1:4; 2nd chromatography: ethyl acetate/toluene 1:9), resulting in the pure product **3** as a colourless solid (4.28 g, 60 %), which is immediately used further.

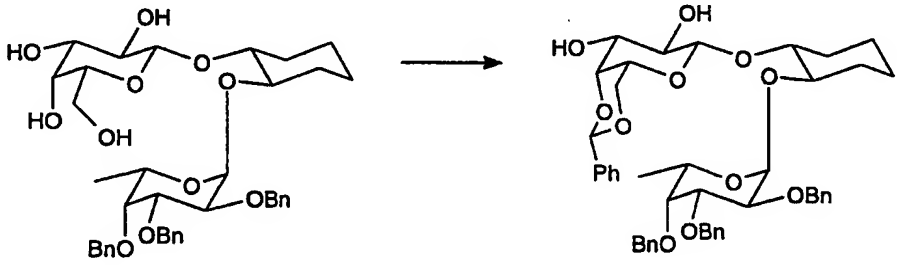
b)



4

A solution of the tetrabenzoate **3** (3.38 g, 3.04 mmol) and sodium methoxide (0.165 g, 3.05 mmol) in dry methanol (32 ml) is stirred at room temperature for 3 hours. The mixture is neutralized by adding a strongly acidic ion exchanger (Amberlyst 15) and then filtered through Hyflo Super Cel®, washing with CH_2Cl_2. The filtrate is concentrated in vacuo, and the remaining yellow oil is purified by flash chromatography on silica gel (elution: CH_2Cl_2/ methanol 19:1), resulting in the pure tetrol **4** (1.95 g, 92 %).

c)

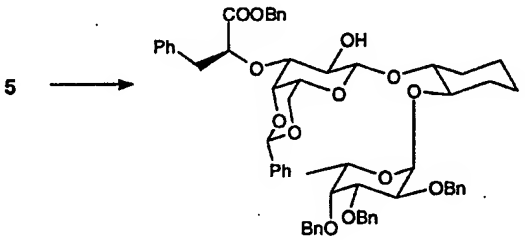


4 5

A solution of the tetrol **4** (1.0 g, 1.44 mmol), benzaldehyde dimethyl acetal (430 ml, 2.86 mmol) and camphorsulfonic acid (0.1 g, 0.43 mmol) in acetonitrile (20 ml) is stirred at room temperature. After 4 hours, further camphorsulfonic acid (0.15 g, 0.65 mmol) is added and the mixture is stirred for a further 6 hours at room temperature, after which it is heated at 35°C for a further 6 hours. Then further camphorsulfonic acid (0.06 g, 0.26 mmol) is added, and the solution is stirred at room temperature for 6 hours. The reaction mixture is filtered through Hyflo Super Cel®, washing with ethyl acetate. The filtrate is extracted by shaking first with saturated aqueous $NaHCO_3$ solution and then with saturated NaCl solution, and the organic phase is dried (Na_2SO_4), filtered and concentrated in vacuo, resulting in 1.5 g of crude product. Purification of the crude product by flash chromatography on silica gel (CH_2Cl_2/MeOH 39:1) affords, besides the required benzylidene acetal **5** (0.475 g),

a mixture of less polar byproducts (0.4 g). The latter are treated once again under the reaction conditions described above and are purified, resulting in a further 0.08 g of the benzylidene acetal 5. The total yield of 5 is: 0.555 g (49 %): ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53 - 7.51 (m, 2H), 7.38 - 7.19 (m, 18H), 5.62 (s, 1H), 4.83 (d, J=3.8 Hz, 1H), 4.77 (d, J=12.1 Hz, 1H), 4.71 (d, J=11.5 Hz, 1H), 4.70 (m, 1H), 4.66 (d, J=12.0 Hz, 1H), 4.62 (d, J=11.5 Hz, 1H), 4.51 (d, J=11.1 Hz, 1H), 4.36 - 4.31 (m, 2H), 4.22 (br d, J=2.8 Hz, 1H), 4.06 (dd, J=1.7, 12.3 Hz, 1H), 3.97 (dd, J=2.9, 10.2 Hz, 1H), 3.92 (d, J=12.0 Hz, 1H), 3.90 (dd, J=3.8, 10.2 Hz, 1H), 3.76 - 3.68 (m, 3H), 3.53 (ddd, J=4.9, 9.0, 11.0 Hz, 1H), 3.43 (br s, 1H), 3.37 (d, J=2.5 Hz, 1H), 2.57 (d, J=8.0 Hz, 1H), 2.51 (s, 1H), 2.08 (m, 2H), 1.73 (br d, J=9.5 Hz, 2H), 1.42 - 1.25 (m, 2H), 1.20 (br t, J=11.2 Hz, 2H), 1.07 (d, J=6.3 Hz, 3H); MS (FAB, THG) 800 (M + NH_4), 783 (M + H).

d)

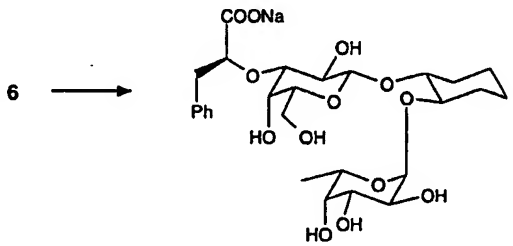


6

A mixture of the diol 5 (0.098 g, 0.125 mmol), di-*n*-butyltin oxide (0.062 g, 0.25 mmol) and methanol (5 ml) is heated under reflux in an argon atmosphere for 2 hours. The reaction mixture is concentrated in vacuo, and pentane is added to the residue, after which it is concentrated once again. Dry CsF (dried under high vacuum at 300°C, 0.068 g, 0.45 mmol) is added under an argon atmosphere, and the mixture is further dried under high vacuum (30 minutes). After addition of anhydrous 1,2-dimethoxyethane (1.5 ml), a solution of benzyl *R*-3-phenyl-2-trifluoromethanesulfonyloxypropionate [Degerbeck, F., Fransson, B., Grehn, L., Ragnarsson, U., J. Chem. Soc. Perkin Trans. 1:11-14 (1993)] (0.24 g, 0.62 mmol) in dry 1,2-dimethoxyethane (1.5 ml) is added. The mixture is first vigorously stirred at room temperature for 4 hours and then at 40°C for a further 2 hours. After addition of aqueous 1M KH_2PO_4 solution, the mixture is diluted with water and extracted three times with ethyl acetate. The combined organic phases are extracted by shaking with diluted aqueous KF solution and then with saturated NaCl solution. The organic phase is dried

(Na_2SO_4), filtered and concentrated in a vacuum rotary evaporator, resulting in the crude product. Purification by flash chromatography on silica gel (gradient elution: ethyl acetate/ toluene 1:4 to 100 % ethyl acetate) affords the ether **6** (0.045 g, 35 %) and the more polar precursor **5** (0.043 g, 44 %): ^{1}H NMR (250 MHz, $CDCl_3$) δ 7.49 (br d, J=6.9 Hz, 2H), 7.37 - 7.05 (m, 28H), 5.36 (s, 1H), 5.04 (d, J=12.0 Hz, 1H), 4.98 (d, J=12.0 Hz, 1H), 4.72 - 4.63 (m, 3H), 4.62 - 4.48 (m, 4H), 4.31 (d, J=11.2 Hz, 1H), 4.16 (m, 1H), 4.11 (d, J=7.9 Hz, 1H), 4.07 (d, J=3.4 Hz, 1H), 3.88 - 3.79 (m, 2H), 3.76 (dd, J=3.4, 10.3 Hz, 1H), 3.66 (d, J=11.3 Hz, 1H), 3.62 - 3.47 (m, 2H), 3.44 - 3.35 (m, 1H), 3.36 (dd, J=3.5, 9.6 Hz, 1H), 3.16 - 3.06 (m, 2H), 3.12 (br s, 1H), 3.01 (dd, J=8.4, 13.9 Hz, 1H), 2.03 - 1.86 (m, 2H), 1.93 (d, J=2.0 Hz, 1H), 1.71 - 1.55 (m, 2H), 1.36 - 1.00 (m, 4H), 0.99 (d, J=7.1 Hz, 3H).

e)

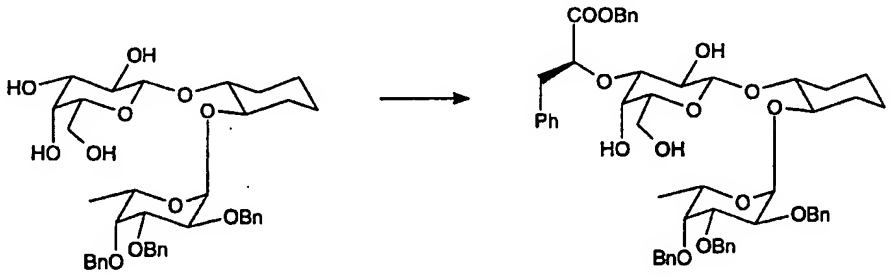


B1.1

Dioxane (2.5 ml), water (1.2 ml) and glacial acetic acid (0.1 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20 %, 0.03 g) and the protected compound **6** (0.03 g, 0.029 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 13 hours, and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The clear filtrate is concentrated and purified by reverse phase chromatography (RP18 silica gel, column diameter 1.4 cm, length 7.0 cm, gradient elution: 40 % MeOH/ H_2O through 45 % MeOH/H_2O to 50 % MeOH/H_2O), resulting in the target molecule **B1.1** (0.015 g, 78 %) as a colourless solid: ^{1}H NMR (500 MHz, D_2O) δ 7.38 - 7.30 (m, 4H), 7.29 - 7.23 (m, 1H), 4.92 (d, J=4.0 Hz, 1H), 4.55 (q, J=6.7 Hz, 1H), 4.35 (d, J=7.8 Hz, 1H), 4.11 (dd, J=4.8, 8.5 Hz, 1H), 3.86 (d, J=3.6 Hz, 1H), 3.84 (dd, J=3.3, 10.5 Hz, 1H), 3.74 (d, J=3.5 Hz,

1H), 3.71 (dd, J=3.9, 10.5 Hz, 1H), 3.69 - 3.62 (m, 3H), 3.50 (ddd, J=1.0, 4.5, 7.1 Hz, 1H), 3.48 - 3.41 (m, 1H), 3.43 (dd, J=8.0, 9.7 Hz, 1H), 3.24 (dd, J=3.5, 9.7 Hz, 1H), 3.09 (dd, J=4.6, 14.0 Hz, 1H), 2.92 (dd, J=8.8, 14.0 Hz, 1H), 2.06 - 1.97 (m, 2H), 1.63 (br s, 2H), 1.24 - 1.14 (m, 4H), 1.13 (d, J=7.0 Hz, 3H); ^{13}C NMR (100.6 MHz, APT, D_2O) d 139.5 (C_q), 130.7 (2 CH), 129.9 (2 CH), 128.0 (CH), 100.8 (CH), 96.8 (CH), 84.0 (CH), 83.3 (CH), 79.6 (CH), 78.4 (CH), 75.6 (CH), 73.3 (CH), 71.4 (CH), 70.9 (CH), 69.2 (CH), 67.7 (CH), 67.4 (CH), 62.8 (CH_2), 40.6 (CH_2), 30.9 (CH_2), 30.4 (CH_2), 24.4 (2 CH_2), 16.6 (CH_3); MS (FAB, THG) 595 (M+Na), 573 (M+H).

f)

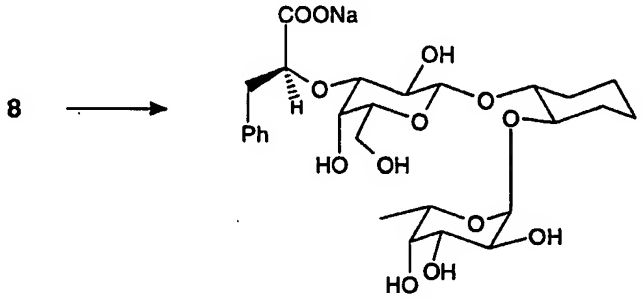


4 8

A mixture of the tetrol 4 (0.038 g, 0.055 mmol) and di-*n*-butyltin oxide (0.029 g, 0.117 mmol) in dry methanol (2.0 ml) is heated under reflux in an argon atmosphere. After 2.25 hours, the clear, colourless solution is concentrated in vacuo, and the residue is mixed with benzene and concentrated several times in order to remove excess MeOH. It is then dried under high vacuum for 30 minutes, and the residue is mixed under an argon atmosphere with CsF (dried under high vacuum at 300°C, 0.03 g, 0.197 mmol) and dry 1,2-dimethoxyethane (0.4 ml). The mixture is cooled to 0°C, and a solution of benzyl R-3-phenyl-2-trifluoromethanesulfonyloxypropionate [Degerbeck, F., Fransson, B., Grehn, L., Ragnarsson, U., J. Chem. Soc. Perkin Trans. 1:11-14 (1993)] (0.085 g, 0.219 mmol) in dry 1,2-dimethoxyethane (0.4 ml) is added using a syringe. The reaction mixture is then warmed to room temperature and stirred for one hour, after which it is stirred at 40°C for a further 2 hours. After addition of aqueous 1M KH_2PO_4 solution, the mixture is diluted with water and extracted three times with CH_2Cl_2. The combined organic phases are washed with aqueous KF solution and then dried (Na_2SO_4), filtered and concentrated in vacuo. Purification of the residue takes place by flash chromatography twice on silica gel (first chromatography: 2 %

MeOH/$CHCl_3$; second chromatography: 45 % ethyl acetate/toluene), resulting in the ether **8** as an oil (0.013 g, 25 %): ^{1}H NMR (250 MHz, $CDCl_3$) δ 7.40 - 7.00 (m, 25H), 5.15 (d, J=11.6 Hz, 1H), 5.09 (d, J=11.6 Hz, 1H), 4.89 (d, J=11.8 Hz, 1H), 4.86 (d, J=3.2 Hz, 1H), 4.77 (d, J=11,6 Hz, 1H), 4.69 (d, J=12.0 Hz, 2H), 4.57 (d, J=12.0 Hz, 1H), 4.56 (d, J=11.8 Hz, 1H), 4.35 (q, J=6.5 Hz, 1H), 4.28 (dd, J=4.0, 9.5 Hz, 1H), 4.11 (d, J=7.6 Hz, 1H), 4.02 - 3.88 (m, 2H), 3.79 (dd, J=7.3, 11.9 Hz, 1H), 3.66 (br s, 1H), 3.63 - 3.40 (m, 5H), 3.22 (m, 1H), 3.10 (dd, J=4.0, 14.0 Hz, 1H), 3.09 (br s, 1H), 3.03 (dd, J=3.5, 9.3 Hz, 1H), 2.90 (dd, J=9.5, 14.0 Hz, 1H), 1.97 - 1.84 (m, 2H), 1.75 (d, J=1.9 Hz, 1H), 1.59 (br s, 2H), 1.29 - 1.07 (m, 4H), 1.01 (d, J=6.4 Hz, 3H).

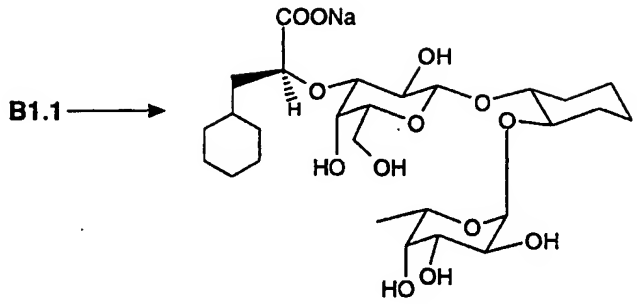
g)



B1.1

1,4-Dioxane/water (2.0 ml of a 4:1 mixture) is added to the protected carbohydrate **8** (0.03 g, 0.032 mmol) and Pd/C (0.03 g, Pd content 10 %), followed by glacial acetic acid (0.1 ml). The flask is evacuated and flushed with argon several times. This procedure is repeated with hydrogen. The mixture is hydrogenated under a slightly elevated pressure of hydrogen with vigorous stirring until a test by thin-layer chromatography (silica gel plates *n*-BuOH: H_2O:acetone:glacial acetic acid: NH_4OH 70:60:50:18:1.5) indicates absence of the precursor and of the intermediates (about 3.5 hours). The black suspension is filtered twice through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. The residue is taken up in water and the solution is passed through an ion exchanger column (Dowex 50, Na^+ form, column diameter 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated and purified by reverse phase chromatography (RP18 silica gel, column diameter 1.4 cm, length 7.0 cm, gradient elution: 40 % MeOH/H_2O through 45 % MeOH/H_2O to 50 % MeOH/H_2O), resulting in the target molecule **B1.1** (0.015 g, 78 %) as a colourless solid.

Example B2: Preparation of compound No. B1.2

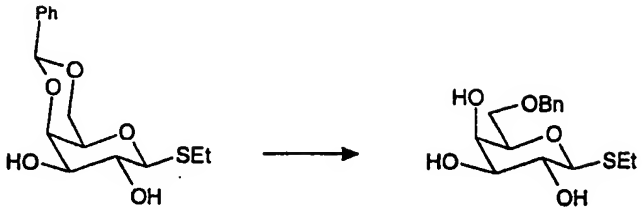


B1.2

The aromatic compound **B1.1** (0.152 g, 0.256 mmol) and 5 % Rh/Al_2O_3 (0.2 g) are taken up in H_2O (5.5 ml), dioxane (3.5 ml) and acetic acid (1.0 ml). Air is replaced by multiple evacuation, firstly by argon and then by hydrogen. The black suspension is hydrogenated under a slightly elevated pressure of hydrogen with vigorous stirring for 2 days and then filtered through a cellulose filter (pore size 45 µm). The clear, colourless solution is concentrated in vacuo, and the residue is taken up in water and concentrated several times in order to remove excess acetic acid. A solution of the crude product in water is filtered through a Dowex 50 ion exchanger column (Na^+ form, length: 9 cm, diameter: 1.3 cm), and the column is washed with water. The filtrate is concentrated in vacuo, and the residue (0.16 g) is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 100 cm, eluent: water, flow rate 0.55 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: 55 % MeOH/H_2O), resulting in the target molecule **B1.2** (0.11 g, 73 %) as a fluffy white solid (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 4.93 (d, J=3.8 Hz, 1H), 4.58 (q, J=6.4 Hz, 1H), 4.43 (d, J=7.5 Hz, 1H), 3.91 (dd, J=3.5, 9.0 Hz, 1H), 3.88 - 3.83 (m, 2H), 3.75 (d, J=3.3 Hz, 1H), 3.73 - 3.64 (m, 4H), 3.57 - 3.53 (m, 1H), 3.49 (dd, J=7.3, 9.0 Hz, 1H), 3.50 - 3.43 (m, 1H), 3.33 (dd, J=3.2, 9.2 Hz, 1H), 2.10 - 1.99 (m, 2H), 1.73 (br d, J=12.0 Hz, 1H), 1.69 - 1.44 (m, 9H), 1.29 - 1.07 (m, 7H), 1.14 (d, J=6.5 Hz, 3H), 0.96 - 0.80 (m, 2H); MS (FAB, THG) 623 (M+Na), 601 (M+H).

Example B3: Preparation of compound No. B1.3

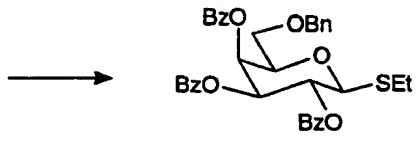
a)



9 10

A suspension consisting of the benzylidene acetal **9** (0.5 g, 1.60 mmol) (EP 671,406), sodium cyanoborohydride (0.9 g, 14.3 mmol), activated 4Å molecular sieves (1.0 g) and dry tetrahydrofuran (30 ml) is cooled to 0°C under a nitrogen atmosphere. The pH of the mixture is adjusted to 1 by cautious addition of a saturated solution of HCl gas in dry diethyl ether. The suspension is stirred at 0°C, and the pH is kept at 1 by occasional addition of the ethereal HCl solution. After 10 hours, cold, saturated aqueous $NaHCO_3$ solution is added (30 ml). The organic phase is separated off, and the aqueous phase is extracted twice with ethyl acetate (70 ml each time). The combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo, resulting in 1.3 g of the crude product. Purification takes place by flash chromatography on silica gel ($CHCl_3$/isopropanol 19:1), resulting in the required 6-benzyl ether **10** (0.3 g, 60 %) and a somewhat less polar byproduct (0.045 g): ^1H NMR (250 MHz, $CDCl_3$) δ 7.47 - 7.33 (m, 5H), 4.64 (s, 2H), 4.37 (d, J=9.3 Hz, 1H), 4.13 (br d, J=3.0 Hz, 1H), 3.89 - 3.69 (m, 4H), 3.64 (dd, J=3.1, 9.0 Hz, 1H), 2.89 - 2.70 (m, 2H), 1.38 (t, J=7.3 Hz, 3H).

b)

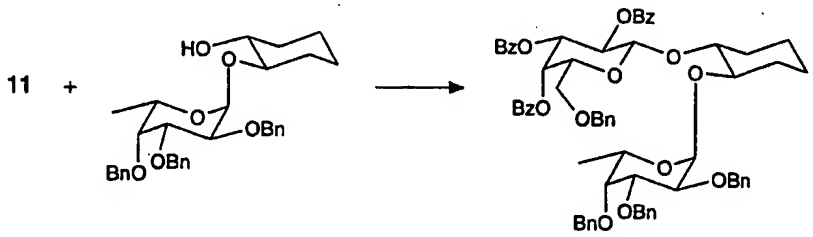


11

Pyridine (0.45 ml, 5.56 mmol) and benzoyl chloride (0.49 ml, 4.22 mmol) are added to a solution of the triol **10** (0.296 g, 0.941 mmol) in CH_2Cl_2 (3.0 ml) at 0°C. The reaction mixture is stirred at 0°C for 3.5 hours and then 1 M aqueous KH_2PO_4 solution is added, and the mixture is extracted three times with CH_2Cl_2. The combined organic phases are washed

with water, dried (Na_2SO_4), filtered and concentrated in vacuo, resulting in 1.0 g of crude product. Purification by flash chromatography on silica gel (hexane/ethyl acetate 4:1) gives the tribenzoate **11** as yellowish crystals (0.517 g, 88 %). ^1H NMR (250 MHz, $CDCl_3$) δ 8.09 (d, J=7.5 Hz, 2H), 8.02 (d, J=7.5 Hz, 2H), 7.85 (d, J=7.5 Hz, 2H), 7.68 (t, J=7.4 Hz, 1H), 7.63 - 7.39 (m, 7H), 7.38 - 7.23 (m, 6H), 6.06 (d, J=3.3 Hz, 1H), 5.85 (t, J=10.0 Hz, 1H), 5.66 (dd, J=3.5, 10.0 Hz, 1H), 4.88 (d, J=10.0 Hz, 1H), 4.60 (d, J=11.9 Hz, 1H), 4.49 (d, J=11.9 Hz, 1H), 4.23 (t, J=6.3 Hz, 1H), 3.84 - 3.64 (m, 2H), 3.02 - 2.80 (m, 2H), 1.38 (t, J=7.5 Hz, 3H).

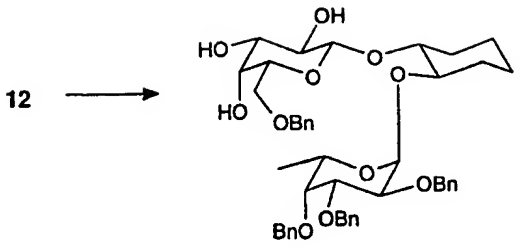
c)



2 **12**

Dry CH_2Cl_2 (8.0 ml) is added to a mixture of the thioglycoside **11** (0.377 g, 0.60 mmol), the glycosyl acceptor **2** (0.32 g, 0.60 mmol) (EP 671,409) and activated 4Å molecular sieves (2.5 g) under an argon atmosphere. A suspension of DMTST (0.39 g, 1.51 mmol) and activated 4Å molecular sieves (0.8 g) in dry CH_2Cl_2 (5.0 ml) is prepared in a second round-bottom flask. Both suspensions are stirred at room temperature for 3.5 hours. Then 3 portions of 1 ml of the DMTST suspension are added over a course of one hour to the glycosyl donor/acceptor mixture. The yellowish reaction mixture is stirred at room temperature for a further 1.5 hours and then filtered through Hyflo Super Cel®, washing with CH_2Cl_2. The filtrate is extracted by shaking with aqueous $NaHCO_3$ solution and then with water. The aqueous phases are reextracted with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo, resulting in 0.67 g of the crude product. Purification takes place by flash chromatography twice on silica gel (first chromatography: toluene/ethyl acetate 14:1; second chromatography: hexane/ethyl acetate 4:1), resulting in the product **12** (0.404 g, 61 %) as a colourless foam.

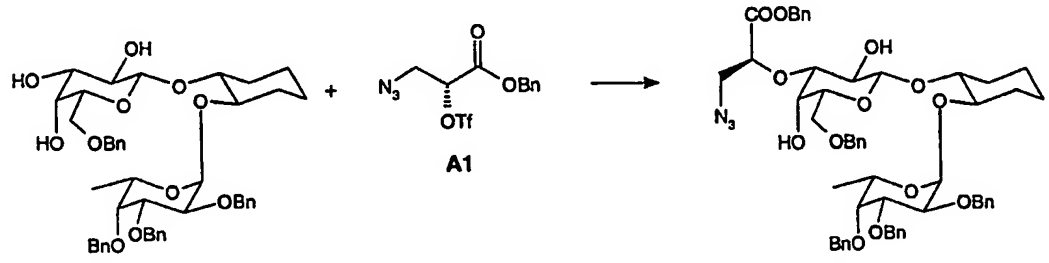
d)



13

A solution of the tribenzoate **12** (3.42 g, 3.12 mmol) and sodium methoxide (0.169 g, 3.12 mmol) in methanol (65 ml) is stirred at room temperature for 6 hours. The base is then neutralized by adding acidic ion exchanger (Amberlyst 15), and the suspension is filtered through Hyflo Super Cel®. The filtrate is concentrated in vacuo, and the remaining yellow oil (3.35 g) is purified by flash chromatography on silica gel (CH_2Cl_2/MeOH, 19:1), resulting in the triol **13** (2.15 g, 88 %) as a colourless foam: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41 - 7.24 (m, 20H), 4.99 (d, J=3.6 Hz, 1H), 4.95 (d, J=11.2 Hz, 1H), 4.83 (d, J=11.2 Hz, 1H), 4.77 (d, J=11.3 Hz, 1H), 4.69 (d, J=11.3 Hz, 1H), 4.68 (d, J=11.5 Hz, 1H), 4.61 (d, J=11.5 Hz, 1H), 4.53 (s, 2H), 4.34 (d, J=7.0 Hz, 1H), 4.33 (m, 1H), 4.04 (dd, J=3.7, 10.1 Hz, 1H), 4.02 (m, 1H), 3.97 (dd, J=2.9, 10.0 Hz, 1H), 3.81 - 3.77 (m, 1H), 3.77 (dd, J=6.0, 9.4 Hz, 1H), 3.70 (dd, J=5.0, 9.6 Hz, 1H), 3.65 (d, J=2.0 Hz, 1H), 3.63 - 3.54 (m, 4H), 2.95 (br s, 1H), 2.60 (br d, J=2.0 Hz, 2H), 2.07 (m, 1H), 2.01 (m, 1H), 1.69 (m, 2H), 1.45 - 1.30 (m, 2H), 1.29 - 1.18 (m, 2H), 1.10 (d, J=6.5 Hz, 3H); MS (FAB, THG) 783 (M-H), 693 (M-$PhCH_2$).

e)

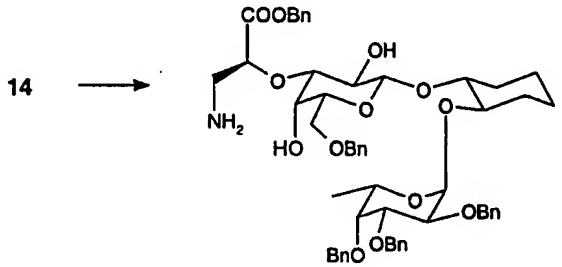


13 A1 14

A mixture of the triol **13** (0.515 g, 0.656 mmol) and di-*n*-butyltin oxide (0.245 g, 0.984 mmol) in dry methanol (15 ml) is heated under reflux in a nitrogen atmosphere for 2 hours. The clear solution is concentrated in vacuo and taken up in benzene and concentrated three

times in order to remove excess MeOH. The residue is dried under high vacuum and then dry CsF (dried under high vacuum at 300°C, 0.5 g, 3.29 mmol) is added under an argon atmosphere, followed by dry 1,2-dimethoxyethane (4.0 ml) and a solution of benzyl *R*-3-azido-2-trifluoromethanesulfonyloxypropionate **A1** (1.16 g, 3.28 mmol) in dry 1,2-dimethoxyethane (8.0 ml). The reaction mixture is stirred at room temperature for 6 hours, and then 1 M aqueous KH_2PO_4 solution (60 ml) is added. The mixture is extracted three times with ethyl acetate, and the combined organic phases are washed first with aqueous $NaHCO_3$ solution and then with NaCl solution, dried (Na_2SO_4), filtered and concentrated in vacuo. The oily residue (1.15 g) is purified by flash chromatography on silica gel (elution of the product with toluene/ethyl acetate 4:1, then elution of the precursor with CH_2Cl_2/MeOH 19:1), resulting in the ether **14** (0.488 g, 75 %) as a colourless foam and the precursor **13** (0.075 g, 15 %). **14**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40 - 7.22 (m, 25H), 5.25 (d, J=11.7 Hz, 1H), 5.16 (d, J=11.8 Hz, 1H), 4.96 (d, J=10.9 Hz, 1H), 4.95 (d, J=3.1 Hz, 1H), 4.82 (d, J=10.8 Hz, 1H), 4.76 (d, J=11.1 Hz, 1H), 4.72 - 4.66 (m, 2H), 4.62 (d, J=11.0 Hz, 1H), 4.57 (dd, J=3.2, 6.0 Hz, 1H), 4.53 (d, J=11.3 Hz, 1H), 4.50 (d, J=11.3 Hz, 1H), 4.39 (q, J=6.2 Hz, 1H), 4.31 (d, J=7.4 Hz, 1H), 4.04 (br s, 1H), 4.02 (dd, J=3.0, 9.5 Hz, 1H), 3.99 (dd, J=2.4, 9.5 Hz, 1H), 3.82 (ddd, J=1.9, 7.3, 8.9 Hz, 1H), 3.77 (dd, J=6.0, 9.2 Hz, 1H), 3.78 - 3.74 (m, 1H), 3.70 - 3.65 (m, 2H), 3.63 (dd, J=3.0, 12.3 Hz, 1H), 3.58 (ddd, J=4.2, 8.0, 9.5 Hz, 1H), 3.53 (dd, J=6.0, 12.5 Hz, 1H), 3.55 - 3.51 (m, 1H), 3.44 (dd, J=3.1, 9.0 Hz, 1H), 2.90 (dd, J=1.2, 1.8 Hz, 1 OH), 2.86 (d, 2.0 Hz, 1 OH), 2.09 - 1.96 (m, 2H), 1.68 (m, 2H), 1.44 - 1.18 (m, 4H), 1.11 (d, J=6.3 Hz, 3H); MS (FAB, THG) 1010 (M+Na), 984 (M+Na+2H-N_2), 962 (M+3H-N_2).

f)

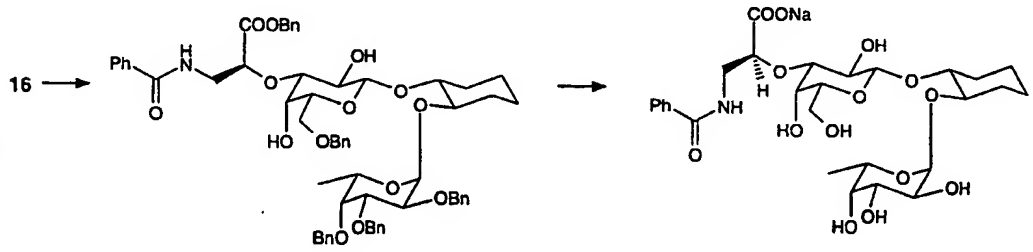


16

$Pt/BaSO_4$ (0.35 g, Pt content: 5 %) is added to a solution of the azide **14** (0.11 g, 0.111 mmol) in ethyl acetate (12 ml). The flask is evacuated and flushed with argon several

times. It is then flushed with hydrogen, and the mixture is hydrogenated under atmospheric pressure with vigorous stirring. The hydrogenation is stopped after 2.5 hours, the suspension is filtered through a cellulose filter (pore size 45 µm), and the fitrate is concentrated in vacuo. The residue (0.115 g) is purified by flash chromatography on silica gel (CH_2Cl_2/MeOH 19:1), resulting not only in the required amine **16** (0.055 g, 51 %) but also the less polar precursor **14** (0.042 g, 38 %). The amine **16** is unstable and is used immediately for further experiments.

g)



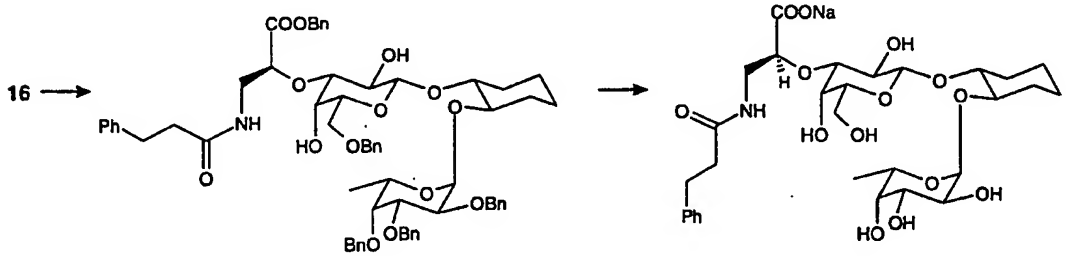
17 **B1.3**

(i) Preparation of the benzamide intermediate **17**: diisopropylethylamine (3.5 ml, 0.02 mmol) and benzotriazol-1-yloxytripyrrolidinophosphonium hexafluorophosphate (PyBOP) (0.012 g, 0.0271 mmol) are added at 0°C to a solution of the β-amino acid derivative **16** (0.013 g, 0.0135 mmol) and benzoic acid (0.0033 g, 0.027 mmol) in dry THF (0.5 ml). The reaction mixture is stirred for 45 minutes, after which saturated aqueous $NaHCO_3$ solution is added. The mixture is extracted three times with CH_2Cl_2, and the combined organic phases are washed first with 1 M aqueous KH_2PO_4 solution (pH 1-2, adjusted with 1 M aqueous HCl) and then with aqueous $NaHCO_3$ solution, dried (Na_2SO_4), filtered and concentrated in vacuo. The residue is purified by column chromatography on silica gel (gradient elution: 35 % ethyl acetate/toluene to 40 % ethyl acetate/toluene), resulting in the benzamide **17** (0.0098 g, 68 %).

(ii) Deprotection of **17**: dioxane (1.5 ml), water (0.7 ml) and glacial acetic acid (0.1 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.011 g) and the benzyl ether **17** (0.0097g, 0.0091 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black mixture is hydrogenated under slightly elevated pressure with vigorous stirring for 14 hours. The mixture is filtered through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. The residue is

taken up in water and concentrated several times in order to remove excess acetic acid. A solution of the crude product with a little water is then passed through an ion exchanger column (Dowex 50, Na^+ form, column diameter 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated in vacuo, and the residue (0.007 g) is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.59 ml/min, detection at 230 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: 37 % MeOH/H_2O to 45 % MeOH/H_2O), resulting in the target molecule **B1.3** (3.3 mg, 58 %) as a fluffy white solid, (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 7.74 (d, J=7.5 Hz, 2H), 7.57 (t, J=7.2 Hz, 1H), 7.48 (t, J=7.6 Hz, 2H), 4.92 (d, J=4.0 Hz, 1H), 4.57 (q, J=6.7 Hz, 1H), 4.44 (d, J=7.8 Hz, 1H), 4.17 (dd, J=3.9, 8.1 Hz, 1H), 3.94 (d, J=3.0 Hz, 1H), 3.86 (d, J=3.5 Hz, 1H), 3.84 (t, J=4.0 Hz, 1H), 3.74 (d, J=3.5 Hz, 1H), 3.75 - 3.65 (m, 4H), 3.60 - 3.52 (m, 3H), 3.49 - 3.44 (m, 1H), 3.45 (dd, J=3.5, 9.3 Hz, 1H), 2.03 (m, 2H), 1.64 (br s, 2H), 1.26 - 1.13 (m, 4H), 1.11 (d, J=6.5 Hz, 3H); MS (FAB, THG) 660 (M+Na), 638 (M+H).

Example B4: Preparation of compound No. B1.4

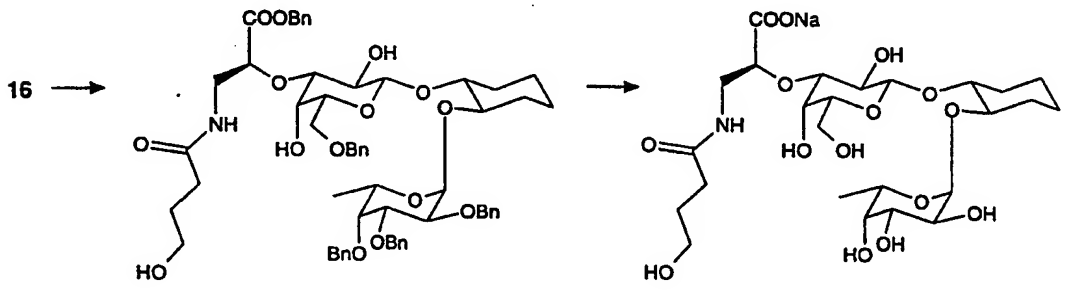


19 B1.4

(a) Preparation of the amide intermediate **19**: diisopropylcarbodiimide (20 ml, 0.129 mmol) is added at room temperature to a solution of the amine **16** (0.032 g, 0.033 mmol), dihydrocinnamic acid (0.015 g, 0.1 mmol), 1-hydroxybenzotriazole (0.025 g, 0.185 mmol) in dry THF (1.0 ml). The reaction mixture is stirred for 30 minutes and then concentrated in vacuo. The residue (0.09 g) is purified by flash chromatography twice on silica gel (eluent for the first chromatography: CH_2Cl_2/MeOH 39:1, for the second chromatography: CH_2Cl_2/isopropanol 39:1), resulting in the pure amide **19** (0.031 g, 86 %).

(b) Deprotection of **19**: dioxane (2.0 ml), water (1.0 ml) and glacial acetic acid (0.5 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.035 g) and the benzyl ether **19** (0.031g, 0.0283 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black mixture is hydrogenated under a slightly elevated pressure of hydrogen with vigorous stirring for 18 hours. The mixture is filtered through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. The residue is mixed with toluene (about 2 ml) and concentrated several times in order to remove excess acetic acid. A solution of the crude product (0.021 g) in a little water is then passed through an ion exchanger column (Dowex 50, Na^+ form, column diameter 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated in vacuo, and the residue (0.02 g) is purified by reverse phase chromatography (Merck RP18 silica gel, column diameter 1.2 cm, length 6 cm, eluent: 60 % $MeOH/H_2O$) and subsequent gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, water, flow rate 0.5 ml/min, detection at 215 nm), resulting in the target molecule **B1.4** (0.014 g, 74 %) as a fluffy colourless solid (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 7.32 (m, 2H), 7.24 (m, 3H), 4.93 (d, J=4,1 Hz, 1H), 4.57 (q, J=6.7 Hz, 1H), 4.40 (d, J=8.0 Hz, 1H), 3.9 - 3.84 (m, 3H), 3.75 - 3.66 (m, 5H), 3.63 (dd, J=3.8, 14.0 Hz, 1H), 3.53 (br dd, J=4.5, 7.5 Hz, 1H), 3.49 (dd, J=7.9, 9.6 Hz, 1H), 3.50 - 3.44 (m, 1H), 3.23 (dd, J=7.8, 14.0 Hz, 1H), 3.15 (dd, J=3.2, 9.8 Hz, 1H), 2.88 (br t, J=7.3 Hz, 2H), 2.59 - 2.45 (m, 2H), 2.09 (m, 1H), 2.03 (m, 1H), 1.67 (br s, 2H), 1.30 - 1.15 (m, 4H), 1.13 (d, J=6.6 Hz, 3H); MS (FAB) 666 (M+H), 643 (M+H-Na).

Example B5: Preparation of compound No. B1.5

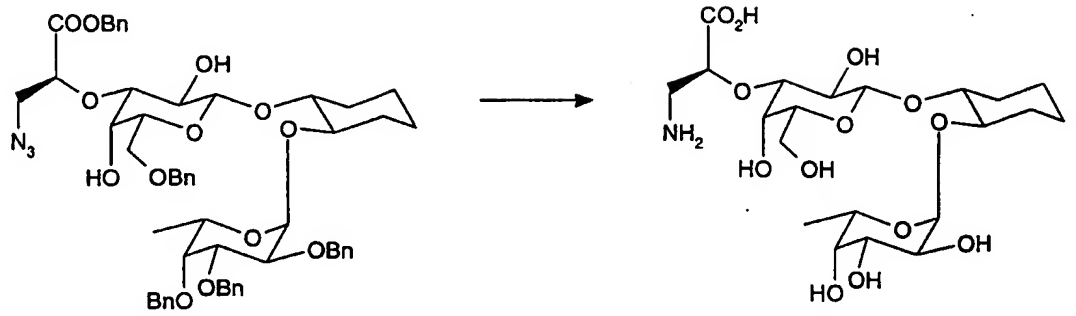


21 B1.5

(a) Preparation of the amide intermediate **21**: diisopropylcarbodiimide (16 ml, 0.103 mmol) is added with stirring at room temperature to a solution of the amine **16** (0.026 g, 0.027 mmol), sodium 4-hydroxybutyrate (0.010 g, 0.079 mmol), 1-hydroxybenzotriazole (0.020 g, 0.148 mmol) in a mixture of dry THF (1.0 ml) and DMF (0.2 ml). After 4 hours, further DMF (dimethylformamide) (0.2 ml) is added, and the mixture is stirred for a further 13 hours. After the volatile constituents (including DMF) have been distilled off under high vacuum, the residue (0.09 g) is purified by flash chromatography on silica gel (CH_2Cl_2/MeOH 29:1), resulting in the amide **21** (0.02 g, 71 %).

(b) Deprotection of **21**: dioxane (2.0 ml), water (1.0 ml) and glacial acetic acid (0.5 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.04 g) and the benzyl ether **21** (0.036 g, 0.034 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black mixture is hydrogenated under a slightly elevated pressure of hydrogen with vigorous stirring for 18 hours. The mixture is filtered through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. The residue is mixed with toluene (about 2 ml) and concentrated several times in order to remove excess acetic acid. A solution of the crude product (0.022 g) in a little water is then passed through an ion exchanger column (Dowex 50, Na^+ form, column diameter 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated in vacuo, and the residue (0.02 g) is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, column diameter 1.2 cm, length 6 cm, eluent: MeOH/H_2O 1:4), resulting in the target molecule **B1.5** (0.015 g, 70 %) as a fluffy colourless solid (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 4.93 (d, J=3.9 Hz, 1H), 4.59 (q, J=6.7 Hz, 1H), 4.47 (d, J=7.5 Hz, 1H), 4.04 (dd, J=3.8, 7.3 Hz, 1H), 3.92 (d, J=3.2 Hz, 1H), 3.86 (dd, J=3.4, 10.2 Hz, 1H), 3.75 (d, J=3.5 Hz, 1H), 3.74 - 3.65 (m, 4H), 3.62 (dd, J=3.9, 14.0 Hz, 1H), 3.59 - 3.51 (m, 2H), 3.55 (t, J=6.3 Hz, 2H), 3.50 - 3.44 (m, 1H), 3.43 (dd, J=3.5, 9.8 Hz, 1H), 3.38 (dd, J=7.5, 14.0 Hz, 1H), 2.27 (t, J=7.4 Hz, 2H), 2.11 - 2.00 (m, 2H), 1.77 (p, J=7.1 Hz, 2H), 1.65 (br s, 2H), 1.29 - 1.13 (m, 4H), 1.15 (d, J=6.8 Hz, 3H). MS (FAB) 643 (M+H-Na), 620 (M+H), 598 (M+2H-Na).

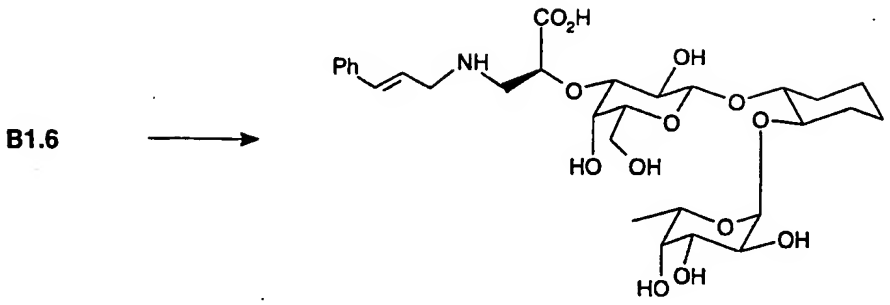
Example B6: Preparation of compound No. B1.6



14 B1.6

Dioxane (2.0 ml), water (1.0 ml) and glacial acetic acid (0.5 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.03 g) and the azide **14** (0.03 g, 0.03 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black mixture is hydrogenated under a slightly elevated pressure of hydrogen with vigorous stirring for 16 hours. The mixture is filtered through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. The residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, water, flow rate 0.55 ml/min, detection 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, column diameter 1.2 cm, length 7 cm, eluent: 25 % $MeOH/H_2O$), resulting in the target molecule **B1.6** (0.011 g, 70 %) as a fluffy colourless solid (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 4.93 (d, J=3.9 Hz, 1H), 4.58 (q, J=6.7 Hz, 1H), 4.48 (d, J=7.9 Hz, 1H), 4.22 (dd, J=3.7, 8.4 Hz, 1H), 3.99 (d, J=3.1 Hz, 1H), 3.86 (dd, J=3.3, 9.9 Hz, 1H), 3.75 (d, J=3.3 Hz, 1H), 3.74 - 3.65 (m, 4H), 3.61 - 3.55 (m, 2H), 3.50 (dd, J=3.0, 9.3 Hz, 1H), 3.48 (m, 1H), 3.35 (dd, J=3.7, 12.9 Hz, 1H), 3.16 (dd, J=8.5, 13.5 Hz, 1H), 2.10 - 2.00 (m, 2H), 1.65 (m, 2H), 1.29 - 1.15 (m, 4H), 1.14 (d, J=6.5 Hz, 3H); MS (FAB, THG) 510 (M-H).

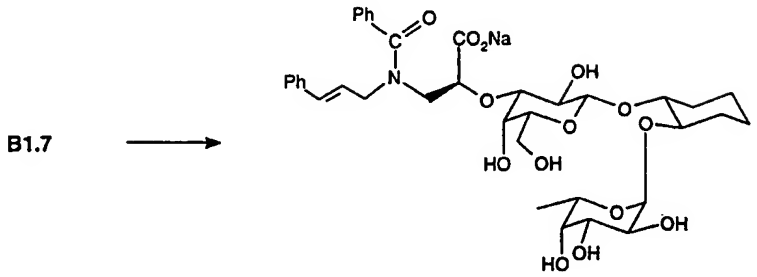
Example B7: Preparation of compound No. B1.7



B1.7

The amine **B1.6** (0.09 g, 0.176 mmol) is dissolved in dry MeOH (1.5 ml) and CH_2Cl_2 (1.8 ml) and activated 3Å molecular sieves (about 0.2 g), cinnamaldehyde (24 µl, 0.19 mmol) and acetic acid (9 µl) are added. The yellowish suspension is stirred for 2 minutes and then $NaBH_3(CN)$ (0.018 g, 0.286 mmol) is added. After 1.5 hours, the mixture is filtered through a cellulose filter (pore size 45 µm), the filter is washed with 1:1 MeOH/ CH_2Cl_2, and the filtrate is concentrated in vacuo. The glassy residue is taken up in water (5 ml), and the solution is acidified (about pH 1-2) with 1 M hydrochloric acid (0.7 ml). The cloudy solution is again filtered through a cellulose filter (pore size 45 µm), and the filtrate is adjusted to pH 7 with 1 M sodium hydroxide solution (about 1 ml) and then concentrated. The residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 100 cm, eluent: water, flow rate 0.6 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: 50 % MeOH/H_2O to 70 % MeOH/ H_2O), resulting in the target molecule **B1.7** (0.03 g, 27 %) as a fluffy white solid (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 7.48 (d, J=8.0 Hz, 2H), 7.41 - 7.31 (m, 3H), 6.83 (d, J=15.4 Hz, 1H), 6.26 (dt, J=15.4, 7.0 Hz, 1H), 4.92 (d, J=3.8 Hz, 1H), 4.56 (q, J=6.3 Hz, 1H), 4.43 (d, J=7.6 Hz, 1H), 4.31 (dd, J=3.5, 8.2 Hz, 1H), 3.98 (d, J=3.0 Hz, 1H), 3.88 - 3.81 (m, 2H), 3.84 (d, J=6.0 Hz, 1H), 3.76 - 3.63 (m, 5H), 3.60 - 3.51 (m, 2H), 3.49 (dd, J=3.0, 10.4 Hz, 1H), 3.49 - 3.41 (m, 1H), 3.41 (dd, J=3.5, 13.2 Hz, 1H), 3.26 (dd, J=8.5, 13.2 Hz, 1H), 2.02 (m, 2H), 1.64 (br s, 2H), 1.27 - 1.12 (m, 4H), 1.12 (d, J=6.3 Hz, 3H); MS (FAB, THG) 650 (M+Na), 628 (M+H).

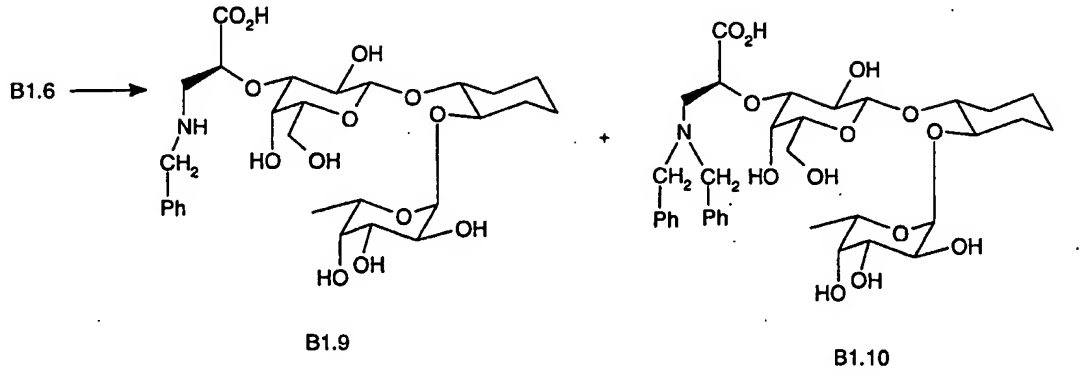
Example B8: Preparation of the compound No. B1.8



B1.8

A solution of the amino acid **B1.7** (0.01 g, 0.0159 mmol) in 1 M aq. $NaHCO_3$ (0.1 ml) is cooled to 0°C and, while stirring vigorously, a 1 M solution of benzoyl chloride in benzene (16.0 µl) is added. After 40 minutes, a further 8.0 µl of the benzoyl chloride solution is added, after 130 minutes a further 3.0 µl and after a total of 3.5 hours a further 1.0 µl. After a total of 4 hours, the reaction mixture is diluted with water and extracted with CH_2Cl_2 in order to remove the excess reagent. The aqueous phase is concentrated in vacuo, and the residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.49 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: 60 % MeOH/H_2O to 70 % MeOH/H_2O), resulting in the target molecule **B1.8** (7.9 mg, 66 %) as a fluffy white solid (after lyophilization). ^1H NMR (500 MHz, D_2O): 1.4:1 mixture of rotamers, characteristic signals: δ 7.52 - 7.24 (m, 10H, 2xPh), 6.71 (d, J=15.5 Hz, 0.42H, PhC<u>H</u>=CH), 6.42 (dt, J=15.5, 6.1 Hz, 0.42H, PhCH=C<u>H</u>), 6.39 (d, J=15.5 Hz, 0.58H, PhC<u>H</u>=CH), 6.13 (dt, J=15.5, 5.6 Hz, 0.58H, PhCH=C<u>H</u>), 4.92 (d, J=4.0 Hz, 1H, Fuc-1H), 1.16 (d, J=7.0 Hz, 1.26H, Fuc-6H), 1.11 (d, J=6.8 Hz, 1.74H, Fuc-6H); MS (FAB, THG) 776 (M+Na), 754 (M+H).

Example B9: Preparation of compound No. B1.9 and No. B1.10



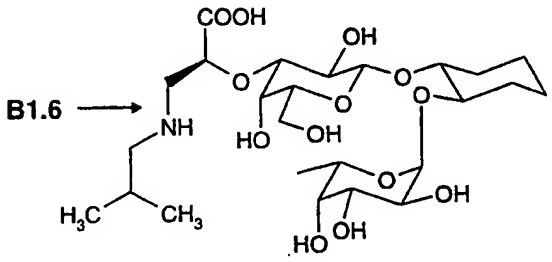
A CH_2Cl_2 solution of freshly distilled benzaldehyde (0.083 g in 1.0 ml CH_2Cl_2, 0.1 ml, 0.078 mmol), activated 3Å molecular sieves (0.1 g) and glacial acetic acid (5 µl, 0.087 mmol) are added to a solution of the amino acid **B1.6** (0.04 g, 0.078 mmol) in MeOH/ CH_2Cl_2 (1:1, 1.0 ml). The suspension is stirred at room temperature and, after 2 minutes, $NaBH_3(CN)$ (0.008 g, 0.129 mmol) is added. After 2.5 hours, a further 15 µl of the benzaldehyde solution are added, and the mixture is stirred for a further hour. The reaction mixture is diluted with water, acidified with dilute acetic acid and filtered through a cellulose filter (pore size 45 µm), and the filtrate is adjusted to pH 8-9 with 1 M aqueous $NaHCO_3$ solution and then concentrated. The residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: 35 % MeOH/H_2O to 60 % MeOH/H_2O), with elution first of the monobenzylamine **B1.9** (0.020 g, 41 %) and then of the dibenzylamine **B1.10** (0.005 g, 9 %).

Monobenzylamine **B1.9**: ^{1}H NMR (500 MHz, D_2O) δ 7.45 (s, 5H), 4.93 (d, J=4.0 Hz, 1H), 4.57 (q, J=6.7 Hz, 1H), 4.45 (d, J=7.6 Hz, 1H), 4.33 (dd, J=3.8, 8.8 Hz, 1H), 4.28 (d, J=13.3 Hz, 1H), 4.24 (d, J=13.3 Hz, 1H), 3.99 (d, J=3.1 Hz, 1H), 3.85 (dd, J=3.5, 10.2 Hz, 1H), 3.74 - 3.65 (m, 5H), 3.59 - 3.54 (m, 2H), 3.49 (dd, J=3.2, 9.7 Hz, 1H), 3.48 - 3.44 (m, 1H), 3.42 (dd, J=3.7, 13.2 Hz, 1H), 3.26 (dd, J=8.9, 13.2 Hz, 1H), 2.04 (m, 2H), 1.65 (br s, 2H), 1.28 - 1.14 (m, 4H), 1.12 (d, J=6.7 Hz, 3H); MS (FAB, THG) 624 (M+Na), 602 (M+H).

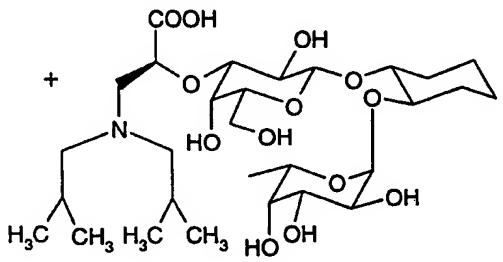
Dibenzylamine **B1.10**: ^{1}H NMR (500 MHz, D_2O): the signals of the 6 H α to the N are very broad at room temperature (d 4.10 - 3.60, 4H and 3.12 - 2.67, 2H) δ 7.38 (s, 10H), 4.93 (d,

J=4.0 Hz, 1H), 4.60 (q, J=6.6 Hz, 1H), 4.43 (d, J=8.0 Hz, 1H), 4.23 (dd, J=3.6, 8.5 Hz, 1H), 3.88 - 3.83 (m, 2H), 3.75 - 3.63 (m, 5H), 3.56 (dd, J=8.0, 9.3 Hz, 1H), 3.53 - 3.44 (m, 2H), 3.32 (dd, J=3.0, 9.5 Hz, 1H), 2.13 - 1.98 (m, 2H), 1.66 (br s, 2H), 1.31 - 1.10 (m, 4H), 1.14 (d, J=6.6 Hz, 3H); MS (FAB, THG) 714 (M+Na), 692 (M+H).

Example B10: Preparation of compounds No. B1.11 and No. B1.12



B1.11



B1.12

A 1 M CH_2Cl_2 solution of isobutyraldehyde (0.156 ml), activated 3Å molecular sieves (0.2 g) and glacial acetic acid (10 µl, 0.17 mmol) are added to a solution of the amino acid **B1.6** (0.08 g, 0.156 mmol) in MeOH/ CH_2Cl_2 (1:1, 2.0 ml). The suspension is stirred at room temperature and, after one minute, $NaBH_3(CN)$ (0.016 g, 0.258 mmol) is added. After 60 minutes, the reaction mixture is diluted with water and filtered through a cellulose filter (pore size 45 µm), and the filtrate is adjusted to pH 8-9 with 1 M aqueous $NaHCO_3$ solution and then concentrated. The residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: 35 % MeOH/H_2O to 50 % MeOH/H_2O), with elution first of the monoisobutylamine **B1.11** (0.041 g, 46 %) and then of the diisobutylamine **B1.12** (0.01 g, 10 %).

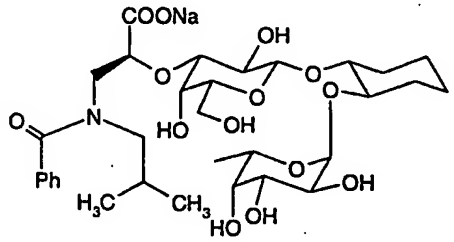
Monoisobutylamine **B1.11**: ^1H NMR (500 MHz, D_2O) δ 4.92 (d, J=4.0 Hz, 1H), 4.59 (q, J=6.7 Hz, 1H), 4.47 (d, J=7.6 Hz, 1H), 4.29 (dd, J=4.0, 9.0 Hz, 1H), 3.98 (d, J=3.5 Hz, 1H), 3.85 (dd, J=3.3, 10.0 Hz, 1H), 3.76 - 3.65 (m, 5H), 3.56 (dd, J=7.5, 9.3 Hz, 1H), 3.59 - 3.54 (m, 1H), 3.50 (dd, J=3.0, 9.7 Hz, 1H), 3.50 - 3.43 (m, 1H), 3.34 (dd, J=3.9, 13.0 Hz, 1H), 3.20 (dd, J=9.2, 13.2 Hz, 1H), 2.90 (dd, J=7.6, 12.0 Hz, 1H), 2.86 (dd, J=7.3, 12.0 Hz, 1H), 2.11 -

1.99 (m, 2H), 1.96 (non, J=6.9 Hz, 1H), 1.65 (m, 2H), 1.28 - 1.11 (m, 4H), 1.14 (d, J=6.6 Hz, 3H), 0.94 (d, J=6.6 Hz, 6H); MS (FAB, THG) 590 (M+Na), 568 (M+H).

Diisobutylamine **B1.12**: ^{1}H NMR (500 MHz, D_2O) δ 4.92 (d, J=4.1 Hz, 1H), 4.59 (q, J=6.7 Hz, 1H), 4.46 (d, J=7.1 Hz, 1H), 4.36 (t, J=6.6 Hz, 1H), 4.02 (br s, 1H), 3.85 (dd, J=3.3, 10.3 Hz, 1H), 3.76 - 3.66 (m, (m, 5H), 3.57 (dd, J=4.7, 7.5 Hz, 1H), 3.55 - 3.50 (m, 2H), 3.49 - 3.39 (m, 3H), 3.07 (br s, 4H), 2.12 (non, J=6.8 Hz, 2H), 2.12 - 1.99 (m, 2H), 1.65 (br s, 2H), 1.28 - 1.11 (m, 4H), 1.13 (d, J=6.7 Hz, 3H), 0.97 (d, J=6.8 Hz, 12H); MS (FAB, THG) 646 (M+Na), 624 (M+H).

Example B11: Preparation of compound No. B1.13

B1.11 ⟶

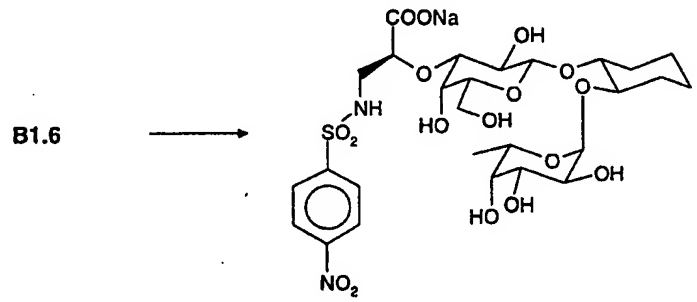


B1.13

A 1 M solution of benzoyl chloride in toluene (41 µl) is added at room temperature to a solution of the amino acid **B1.11** (0.020 g, 0.0339 mmol) in 1 M aqueous $NaHCO_3$ (100 µl). The mixture is stirred vigorously and, after 1 hour, further benzoyl chloride (41 µl of the 1 M solution) is added. After the reaction is complete, the volatile constituents are removed under high vacuum, and the residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: 45 % MeOH/H_2O) and then lyophilized, resulting in the benzamide **B1.13** as a fluffy powder, (0.014 g, 59 %). ^{1}H NMR (500 MHz, D_2O): 1:1 rotamer mixture: δ 7.50 - 7.37 (m, 5H), 4.93 (d, J=4.0 Hz, 0.5H), 4.92 (d, J=4.0 Hz, 0.5H), 4.60 (q, J=6.4 Hz, 1H), 4.48 (d, J=8.0 Hz, 0.5H), 4.37 (d, J=8.0 Hz, 0.5H), 4.32 (dd, J=4.5, 8.0 Hz, 0.5H), 4.02 (dd, J=4.3, 8.7 Hz, 0.5H), 3.94 (d, J=3.2 Hz, 0.5H), 3.89 - 3.83 (m, 1.5H), 3.82 - 3.61 (m, 7H), 3.60 - 3.52 (m, 1.5H), 3.51 - 3.43 (m, 2.5H), 3.25 (dd, J=7.9, 14.2 Hz, 0.5H), 3.20 (dd, J=7.9, 14.2 Hz,

0.5H), 3.17 - 3.10 (m, 1H), 2.16 - 1.97 (m, 2.5H), 1.86 (non, J=6.9 Hz, 0.5H), 1.65 (br s, 2H), 1.29 - 1.14 (m, 4H), 1.17 (d, J=6.4 Hz, 1.5H), 1.11 (d, J=6.6 Hz, 1.5H), 0.95 (d, J=6.5 Hz, 1.5H), 0.92 (d, J=6.6 Hz, 1.5H), 0.65 (d, J=6.4 Hz, 1.5H), 0.65 (d, J=6.5 Hz, 1.5H); MS (FAB, THG) 716 (M+Na), 694 (M+H).

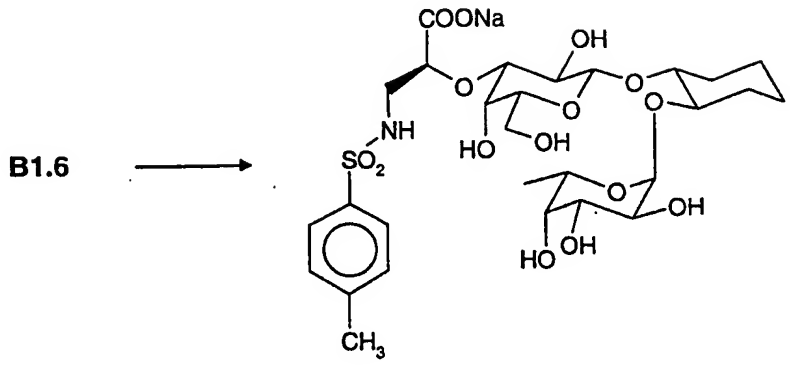
Example B12: Preparation of compound No. B1.14

B1.6 

B1.14

A 1 molar solution of *p*-nitrobenzenesulfonyl chloride in toluene (43 µl) is added with vigorous stirring to a solution of the amino acid **B1.6** (0.02 g, 0.039 mmol) in 1 molar aqueous $NaHCO_3$ solution (0.2 ml). The reaction mixture is stirred at room temperature for 16 hours and then concentrated in vacuo. The residue is taken up in water (0.3 ml) and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm). The crude product (0.025 g) is further purified by two reverse phase chromatographies (Merck RP18 silica gel, 1st chromatography: elution with 50 % MeOH/H_2O; 2nd chromatography: elution with 40 % MeOH/H_2O) and subsequently lyophilized, resulting in the target compound as a fluffy powder (0.0105 g, 39 %). ^1H NMR (400 MHz, D_2O) δ 8.39 (m, 2H), 8.07 (m, 2H), 4.93 (d, J=4.0 Hz, 1H), 4.56 (q, J=6.6 Hz, 1H), 4.43 (d, J=7.9 Hz, 1H), 3.96 (dd, J=3.5, 7.1 Hz, 1H), 3.88 - 3.83 (m, 2H), 3.76 - 3.64 (m, 5H), 3.54 - 3.44 (m, 3H), 3.38 (dd, J=3.5, 13.7 Hz, 1H), 3.33 (dd, J=3.2, 9.6 Hz, 1H), 3.19 (dd, J=7.3, 13.7 Hz, 1H), 2.05 (br t, J=13.4 Hz, 2H), 1.66 (br s, 2H), 1.30 - 1.12 (m, 4H), 1.14 (d, J=6.6 Hz, 3H); MS (FAB, THG) 719 (M+Na), 697 (M+H).

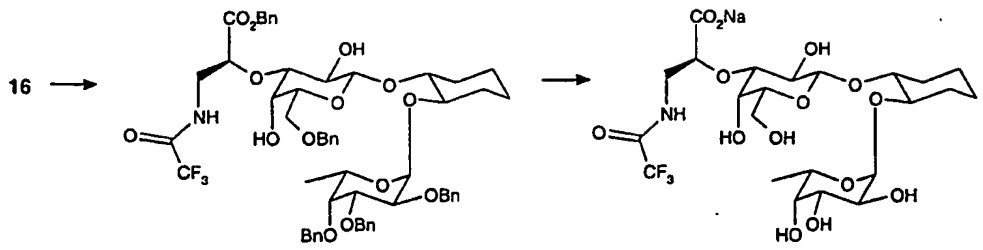
Example B13: Preparation of compound No. B1.15



B1.15

A 1 molar solution of *p*-toluenesulfonyl chloride in toluene (22 µl) is added at 0°C with vigorous stirring to a solution of the amino acid **B1.6** (0.01 g, 0.02 mmol) in 1 molar aqueous $NaHCO_3$ solution (0.1 ml). The reaction mixture is stirred at 0°C for 90 minutes, after which further *p*-toluenesulfonyl chloride (10 µl of the 1 M solution) is added. The reaction mixture is then warmed to room temperature, stirred for 18 hours and then concentrated in vacuo. The residue is taken up in water and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution with 45 % MeOH/H_2O) and subsequently lyophilized, resulting in the target compound as a fluffy powder (0.004 g, 30 %). ^{1}H NMR (400 MHz, D_2O) δ 7.69 (d, J=8.2 Hz, 2H), 7.37 (d, J=8.1 Hz, 2H), 4.88 (d, J=3.9 Hz, 1H), 4.52 (q, J=6.6 Hz, 1H), 4.35 (d, J=7.9 Hz, 1H), 3.85 - 3.78 (m, 2H), 3.74 (d, J=2,8 Hz, 1H), 3.71 - 3.56 (m, 5H), 3.50 - 3.39 (m, 3H), 3.29 (dd, J=3.4, 13.8 Hz, 1H), 3.10 (dd, J=3.1, 9.6 Hz, 1H), 3.03 (dd, J=8.0, 13.8 Hz, 1H), 2.34 (s, 3H), 2.08 - 1.93 (m, 2H), 1.61 (br s, 2H), 1.26 - 1.07 (m, 4H), 1.09 (d, J=6.6 Hz, 3H).

Example B14: Preparation of compound No. B1.16



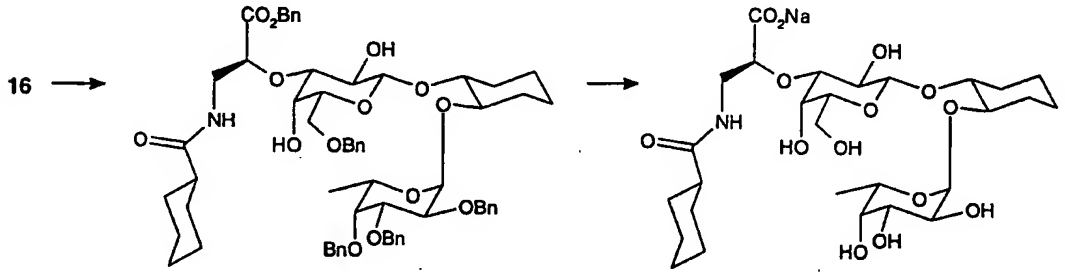
24 B1.16

Pentafluorophenyl trifluoroacetate (4.5 ml, 0.026 mmol) is added at room temperature with stirring to a solution of the isoserine derivative **16** (0.025 g, 0.026 mmol) and triethylamine (0.7 ml, 0.005 mmol) in DMF (100 ml). After 15 min, further pentafluorophenyl trifluoroacetate (2.5 ml, 0.015 mmol) is added. 30 minutes later, further triethylamine (2.8 ml, 0.02 mmol) and pentafluorophenyl trifluoroacetate (4.5 ml, 0.026 mmol) are added. The same amount of the latter reagent is added once again 20 minutes later. The mixture is stirred for a further 45 minutes and then saturated aqueous $NaHCO_3$ solution (0.2 ml) is added, and the mixture is diluted with water and extracted several times with ethyl acetate. The combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The crude product (0.04 g) is purified by flash chromatography on silica gel as eluent: ethyl acetate/toluene 1:3), resulting in the trifluoroacetamide **24** (0.022 g, 83 %).

Deprotection of **24**: dioxane (1.4 ml), water (0.7 ml) and glacial acetic acid (0.35 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20 %, 0.02 g) and the benzyl ether **24** (0.021g, 0.021 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black mixture is hydrogenated under slightly elevated pressure for 3.5 hours. The reaction mixture is filtered through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. A solution of the residue in a little water is passed through an ion exchanger column (Dowex 50, Na^+ form, column diameter 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated in vacuo, and the residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, column diameter 1.2 cm, length 7 cm, gradient elution: 30 % MeOH/H_2O to 40 % MeOH/H_2O), resulting in the target

molecule **B1.16** (0.0085 g, 68 %) as a fluffy colourless solid (after lyophilization). ^{1}H NMR (500 MHz, D_2O) δ 4.93 (d, J=3.9 Hz, 1H), 4.59 (q, J=6.5 Hz, 1H), 4.45 (d, J=8.2 Hz, 1H), 4.08 (dd, J=3.4, 8.2 Hz, 1H), 3.91 (d, J=3.1 Hz, 1H), 3.86 (dd, J=3.1, 10.0 Hz, 1H), 3.75 (d, J=3.1 Hz, 1H), 3.72 (dd, J=3.9, 10.0 Hz, 1H), 3.73 - 3.65 (m, 4H), 3.61 - 3.50 (m, 3H), 3.50 - 3.44 (m, 1H), 3.42 (dd, J=3.1, 9.6 Hz, 1H), 2.10 - 2.00 (m, 2H), 1.65 (m, 2H), 1.28 - 1.15 (m, 4H), 1.14 (d, J=6.5 Hz, 3H); MS (FAB, THG) 652 (M+Na), 630 (M+H), 608 (M+2H-Na).

Example B15: Preparation of compound No. B1.17



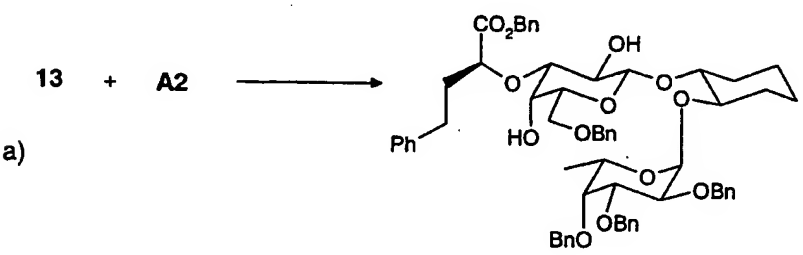
26 **B1.17**

(a) Preparation of the amide **26**. Diisopropylcarbodiimide(17 ml, 0.11 mmol) is added at room temperature with stirring to a mixture of the amine **16** (0.027 g, 0.028 mmol), cyclohexanecarboxylic acid (0.011 g, 0.086 mmol), 1-hydroxybenzotriazole (0.021 g, 0.155 mmol) and dry THF (0.9 ml). After 20 minutes, dry DMF (0.4 ml) is added, and the mixture is stirred for a further hour. The reaction mixture is concentrated in vacuo, and the remaining DMF removed under high vacuum. The residue is purified by flash chromatography on silica gel (CH_2Cl_2/isopropanol 39:1), resulting in the amide **26** (0.024 g, 80 %).
(b) Deprotection of **26**: dioxane (2.0 ml), water (1.0 ml) and glacial acetic acid (0.5 ml) are added to a mixture of $Pd(OH)_2$/C (Pearlman catalyst, Pd content 20%, 0.03 g) and the benzyl ether **26** (0.024 g, 0.022 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black mixture is hydrogenated under slightly elevated pressure for 18 hours. The reaction mixture is filtered through a cellulose filter (pore size 45 µm), and the filtrate is concentrated in vacuo. A solution of the residue in a little water is passed through an ion exchanger column (Dowex 50, Na^+ form, column diameter 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated

in vacuo, and the residue is purified by gel filtration on Bio-Gel P2 (particle size 65 µm , column diameter 2.5 cm, length 35 cm, water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, column diameter 1.2 cm, length 6 cm, eluent: MeOH/H_2O 3:2), resulting in the target molecule **B1.17** (0.008 g, 56 %) as a fluffy colourless solid (after lyophilization). ^1H NMR (500 MHz, D_2O) δ 4.93 (d, J=4.0 Hz, 1H), 4.60 (q, J=6.7 Hz, 1H), 4.47 (d, J=8.0 Hz, 1H), 4.04 (dd, J=3.8, 7.5 Hz, 1H), 3.92 (d, J=2.8 Hz, 1H), 3.86 (dd, J=3.2, 10.3 Hz, 1H), 3.75 (d, J=3.3 Hz, 1H), 3.74 - 3.64 (m, 4H), 3.61 (dd, J=3.8, 13.8 Hz, 1H), 3.59 - 3.52 (m, 2H), 3.50 - 3.44 (m, 1H), 3.42 (dd, J=3.3, 9.8 Hz, 1H), 3.35 (dd, J=7.7, 14.0 Hz, 1H), 2.19 (tt, J=3.3, 11.5 Hz, 1H), 2.11 - 2.00 (m, 2H), 1.78 - 1.57 (m, 7H), 1.34 - 1.08 (m. 9H), 1.15 (d, J=6.5 Hz, 3H); MS (FAB, THG) 644 (M + H), 622 (M+ 2H - Na).

Example B16: Preparation of the compound B1.18

a)

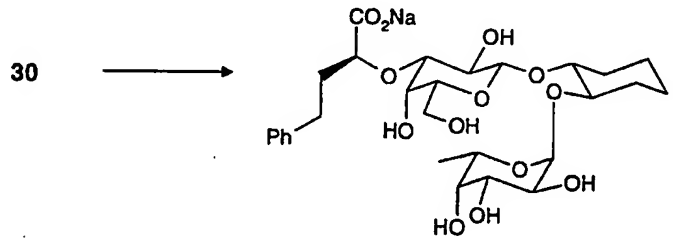


30

A solution of the triol **13** (0.129 g, 0.17 mmol) in dry MeOH (4.0 ml) and di-n-butyltin oxide (0.064 g, 0.258 mmol) is boiled under reflux in an argon atmosphere for 2 hours. The clear solution is concentrated in vacuo, and the residue is mixed with pentane (2 ml), again concentrated and then dried under high vacuum for 30 minuten in order to remove remaining MeOH. The residue is mixed under an argon atmosphere with dry CsF (0.131 g, 0.86 mmol, weighed under argon) and dry 1,2-dimethoxyethan (0.5 ml) followed by a solution of benzyl (R)-4-phenyl-2-trifluoromethanesulfonyloxybutyrate (**A2**) (0.3 g, 0.861 mmol) in dry 1,2-dimethoxyethane (1.0 ml). The reaction mixture is stirred at room temperature for 75 minutes and 1 M of aqueous KH_2PO_4 is added, and the mixture is diluted with water and extracted with ethyl acetate (phase separation is facilitated by adding a little aqueous KF solution). The organic extracts are combined, dried with Na_2SO_4, filtered and concentrated in vacuo,

resulting in the crude product as an oil (0.39 g). Purification by flash chromatography on silica gel (eluent: toluene/ethyl acetate 5:1) results in the pure ether **30** (0.143 g, 81 %). ^{1}H NMR (250 MHz, $CDCl_3$) δ 7.35 - 7.05 (m, 30H), 5.13 (d, J=12.1 Hz, 1H), 5.03 (d, J=12.1 Hz, 1H), 4.88 (d, J=11.4 Hz, 1H), 4.87 (d, J=2.0 Hz, 1H), 4.78 - 4.50 (m, 5H), 4.46 (d, J=12,5 Hz, 1H), 4.40 (d, J=12.5 Hz, 1H), 4.33 (q, J=6.5 Hz, 1H), 4.24 (d, J=7.8 Hz, 1H), 4.09 (dd, J=4.0, 8.5 Hz, 1H), 3.93 (br s, 2H), 3.80 - 3.38 (m, 7H), 3.26 - 3.17 (m, 2H), 2.86 - 2.62 (m, 2H), 2.59 (d, J=2.0 Hz, 1 OH), 2.29 (br s, 1 OH), 2.11 - 1.85 (m, 4H), 1.67 - 1.52 (m, 2H), 1.40 - 1.06 (m, 4H), 1.03 (d, J=6.5 Hz, 3H).

b)

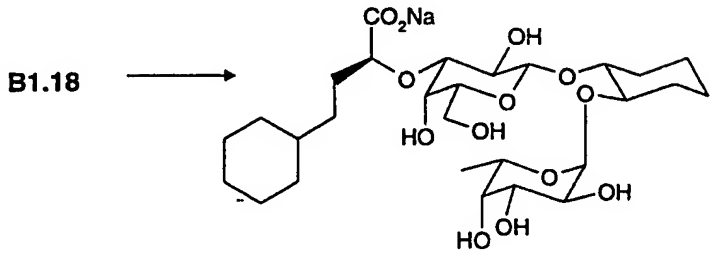


B1.18

The benzyl ether **30** (0.14 g, 0.135 mmol) is dissolved in dioxane (4 ml) and water (2 ml), glacial acetic acid (1 ml) and 20% $Pd(OH)_2$/C (0.14 g) are added.The air in the reaction vessel is replaced initially by argon, by evacuation and flushing several times, and then by hydrogen. The black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen for 90 minutes and then filtered through a cellulose filter (pore size 45 µm), washing with water. The filtrate is concentrated, and the residue is taken up in toluene and concentrated several times in order to remove remaining acetic acid. The crude product (0.095 g) is dissolved in a little water and filtered through a Dowex50 (Na^+) ion exchanger column. The filtrate is freeze-dried and the residue (0.085 g) is purified by reverse phase chromatography (Merck RP18 silica gel, elution: 40 % MeOH/H_2O) and subsequent gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and then lyophilized, resulting in the target compound **B1.18** as a fluffy powder (0.045 g, 55 %). ^{1}H NMR (500 MHz, D_2O) δ 7.35 - 7.27 (m, 4H), 7.22 (tt, J=1.5, 7.0 Hz, 1H), 4.93 (d, J=4.0 Hz, 1H), 4.60 (q, J=6.7 Hz, 1H), 4.47 (d, J=7.8 Hz, 1H), 3.89 - 3.82 (m, 3H), 3.76 (d, J=3.5 Hz, 1H), 3.74 - 3.63 (m, 4H), 3.59 - 3.52 (m, 2H), 3.51 - 3.45 (m, 1H), 3.37 (dd, J=3.5, 9.8 Hz, 1H), 2.80 - 2.68 (m, 2H), 2.12 - 1.99

(m, 3H), 1.98 - 1.89 (m, 1H), 1.65 (br s, 2H), 1.30 - 1.13 (m, 4H), 1.15 (d, J=6.6 Hz, 3H); MS (FAB, THG) 609 (M+Na), 587 (M+H).

Example B17: Preparation of the compound No. B1.19

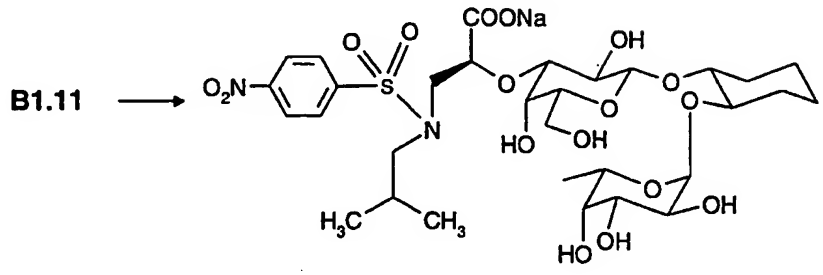


B1.19

The aromatic compound **B1.18** (0.02 g, 0.033 mmol) is dissolved in water (1.8 ml), dioxane (1.2 ml), glacial acetic acid (0.3 ml). and 5% Rh/Al_2O_3 (0.04 g) is added. The air in the reaction vessel is replaced by hydrogen by evacuation and flushing several times, and the mixture is hydrogenated under a slightly elevated pressure of hydrogen with vigorous stirring for 1.5 days. It is then filtered through a cellulose filter (pore size 45 µm) and washed with water, the filtrate is concentrated, and the residue is taken up in toluene and concentrated several times in order to remove remaining acetic acid. The crude product is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and then hydrogenated again under the above conditions for 2 days. The reaction mixture is then filtered through a cellulose filter (pore size 45 µm) and washed with water, and the filtrate is concentrated, after which the residue is taken up in toluene and concentrated several times. The crude product is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: 50 % $MeOH/H_2O$) and subsequently lyophilized, resulting in the target compound **B1.19** as a fluffy powder (0.01 g, 50 %). ^1H NMR (250 MHz, D_2O) δ 4.83 (d, J=4.0 Hz, 1H), 4.48 (q, J=6.7 Hz, 1H), 4.35 (d, J=7.8 Hz, 1H), 3.81 - 3.69 (m, 3H), 3.67 - 3.53 (m, 5H), 3.49 - 3.31 (m, 3H), 3.25 (dd, J=3.1, 9.7 Hz, 1H),

2.03 - 1.87 (m, 2H), 1.72 - 1.38 (m, 9H), 1.24 - 0.97 (m, 10H), 1.04 (d, J=6.6 Hz, 3H), 0.75 (br s, 2H); MS (FAB, THG) 615 (M+Na), 593 (M+H).

Example B18: Preparation of the compound B1.38

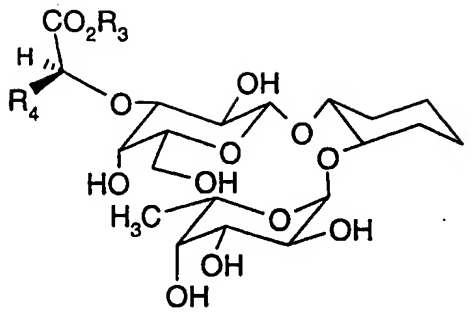


B1.38

A solution of *p*-nitrobenzenesulfonyl chloride in toluene (1 M, 150µl) is added to a solution of amino acid **B1.11**(0.035 g, 0.0617 mmol) in 1 molar aqueous $NaHCO_3$ solution (315 µl). The mixture is vigorously stirred at room temperature and, after 17 hours, further *p*-nitrobenzenesulfonyl chloride solution (120 µl) is added. The reaction mixture is stirred for a further 24 hours, then diluted with water and washed twice with ethyl acetate. The aqueous phase is concentrated to a volume of 0.5 ml in vacuo, and this solution is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 100 cm, eluent: water, flow rate 0.5 ml/min, detection at 215 nm). The crude product (0.06g) is then further purified by reverse phase chromatography three times (Merck RP 18 silica gel, elution: 40% MeOH/H_2O) and then lyophilized, resulting in the sulfonamide **B1.38** (0.013 g, 27%) as a colourless fluffy powder. ^{1}H NMR (400 MHz, D_2O) δ 8.34 (m,2H), 8.05(m, 2H), 4.88 (d, J=4.0Hz, 1H), 4.53 (q,J=6.5Hz, 1H), 4.38 (d, J=7.9 Hz, 1H) 4.06 (dd, J=3.9, 8.2 Hz, 1H) 3.84-3.79 (m, 2H), 3.70 (d, J=3.0 Hz, 1H), 3.67 (dd, J=3.9, 10.4 Hz, 1H), 3.69 - 3.58 (m, 3H), 3.57 - 3.38 (m, 5H) 3.25 (dd, J=3.2, 9.5 Hz, 1H) 3.10 (dd, J=7.7, 14.1 Hz, 1H) 3.05 (dd, J=7.7, 14.1 Hz, 1H), 2.07-1.94 (m, 2H) 1.89 (hep, J=6.7 Hz, 1H), 1.61 (br s, 2H), 1.25 -1.07 (m, 4H), 1.10 (d, J=6.6 Hz, 3H) 0.70 (d, J=6.6 Hz, 3H), 0.63 (d, J=6.6Hz, 3H).

The following compounds are prepared in analogy to the above examples:

Table 1:



Preparation according to Example No.	Compound No.	R_3	R_4	FAB-MS THG
B15	B1.20	Na	$CH_2NHC(O)C_{11}H_{23}$	716(M+H) 738(M+Na)
B15	B1.21	Na	$CH_2NHC(O)CH(C_6H_5)_2$	728(M+H) 750(M+Na)
B12[(1)]	B1.22	Na	$CH_2NHC(O)C_2H_4CO_2Na$	656(M+H) 678(M+Na)
B15	B1.23	Na	$CH_2NHC(O)C_6[(1,3,4,5)OH]_4H_7$ quinamide	708(M+H) 730(M+Na)
B15	B1.24	Na	$CH_2NHC(O)C_6H_4$ -p-SO_3Na	740(M+H) 762(M+Na)
B12	B1.25	Na	$CH_2NHC(O)C_6H_4Cl$	672(M+H) 694(M+Na)
B12	B1.26	Na	$CH_2NHC(O)C_6H_4NO_2$	683(M+H) 705(M+Na)
B12	B1.27	Na	$CH_2NHC(O)C_6H_4OCH_3$	668(M+H) 690(M+Na)
B12	B1.28	Na	$CH_2NHC(O)C_6H_4(3,4)Cl_2$	706(M+H) 728(M+Na)
B12	B1.29	Na	$CH_2NHC(O)C_6H_4CH_3$	652(M+H) 674(M+Na)
B12[(2)]	B1.30	Na	$CH_2NHC(O)C_6H_4C_6H_5$	714(M+H) 736(M+Na)

Preparation according to Example No.	Compound No.	R_3	R_4	FAB-MS THG
B12[3]	B1.31	Na	$CH_2NHC(O)C_6H_4CN$	663(M+H) 685(M+Na)
B12	B1.32	Na	$CH_2NHC(O)C_{10}H_7$	688(M+H) 710(M+Na)
B12[4]	B1.33	Na	$CH_2NHC(O)C_6H_4COONa$	704(M+H) 726(M+Na)
B12[5]	B1.34	Na	$CH_2NHC(O)(CHOH)_2COONa$	688(M+H) 710(M+Na)
B11	B1.35	Na	$CH_2N[C(O)C_6H_5]CH_2C_6H_5$	728(M+H) 750(M+Na)
B11	B1.36	Na	$CH_2N[C(O)C_6H_5](CH_2)_3C_6H_5$	756(M+H) 778(M+Na)
B15[6]	B1.37	Na	$CH_2NHSO_2CF_3$	666(M+H) 688(M+Na)

[1] using a solution of succinic anhydride in DMF as reagent

[2] using a solution of pentafluorophenyl biphenylcarboxylate in dioxane as reagent

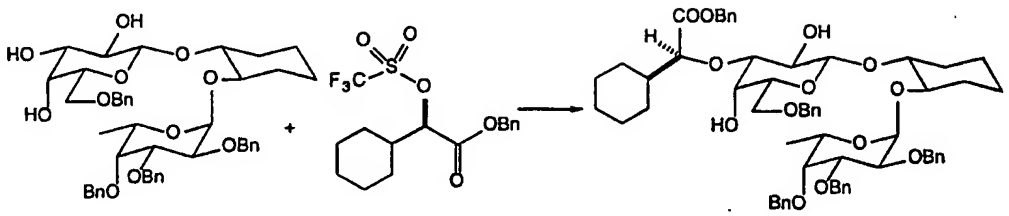
[3] using a solution of pentafluorophenyl p-cyanobenzoate in dioxane as reagent

[4] using a solution of methyl pentafluorophenyl terephthalate in dioxane as reagent. After completion of amide formation, 1 M aqueous NaOH is added to the reaction mixture, which is heated at 65°C until hydrolysis of the methyl ester is complete.

[5] 1M NaOH is used in place of 1M $NaHCO_3$. A solution of (+)-di-O-acetyl-L-tartaric anhydride in dioxane is used as reagent.

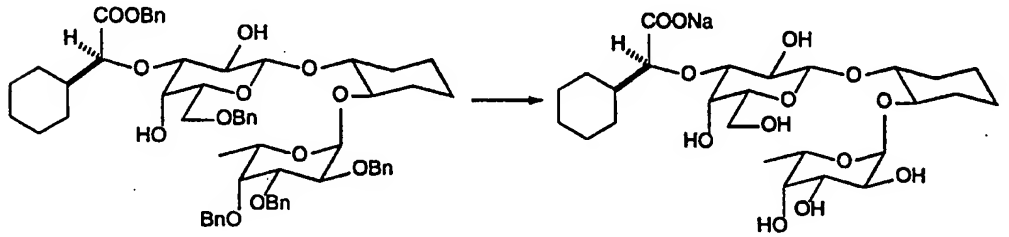
[6] The formation of the amide takes place in CH_2Cl_2 at 0°C using trifluoromethanesulfonic anhydride as reagent.

Example B19: Preparation of compound No. B1.39



13 A3 31

A suspension of **13** (0.086 g, 0.11 mmol) and di-*n*-butyltin oxide (0.05 g, 0.19 mmol) in dry benzene (3.3 ml) is boiled under reflux in an argon atmosphere for 12 hours. The reaction mixture is concentrated in vacuo and dried under high vacuum for one hour. Then CsF (dried under high vacuum at 300°C for several hours, 0.042 g, 0.274 mmol) is added under an argon atmosphere, followed by dry 1,2-dimethoxyethane (0.6 ml) and a solution of triflate **A3** (0.25 g, 0.66 mmol) in dry 1,2-dimethoxyethane (0.4 ml). The reaction mixture is heated to 35 to 40°C and stirred at this temperature for 5 hours. Then a solution of 15% KF in 1M aqueous KH_2PO_4 solution (30 ml) is added, and the mixture is extracted three times with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The oily residue (0.16 g) is purified by column chromatography on silica gel (gradient elution: toluene/ethyl acetate 80:20 to 75:25, then CH_2Cl_2/MeOH 19:1), resulting in the ether **31** (0.049 g, 44 %) as a colourless foam and the precursor **13** (0.035 g, 40 %).

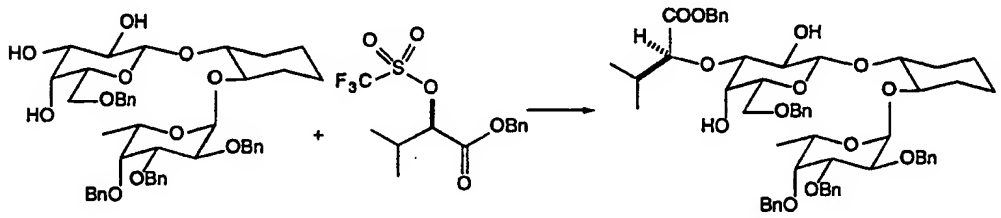


31 B1.39

Dioxane (2.0 ml), water (1.0 ml) and glacial acetic acid (0.5 ml) are added to a mixture of $Pd(OH)_2$/C (Pearlman catalyst, Pd content 20%, 0.028 g) and the benzyl ether **31** (0.048 g, 0.047 mmol). The flask is evacuated and flushed with argon several times. It is then

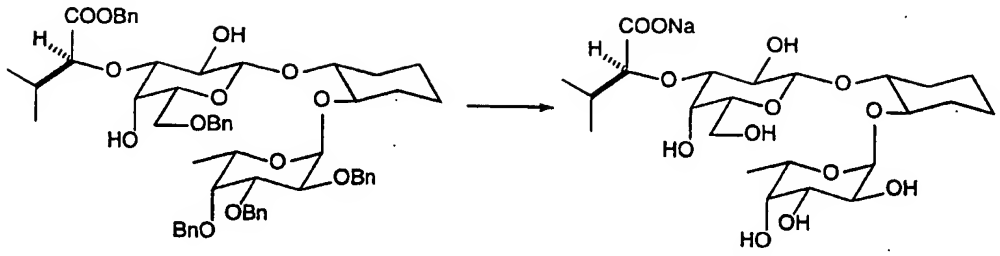
flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 17 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm) washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 230 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution with 7:3 H_2O/methanol), resulting in the target molecule **B1.39** (0.014 g, 51 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 4.83 (d, J=4.0 Hz, 1H), 4.49 (q, J=6.6 Hz, 1H), 4.33 (d, J=7.7 Hz, 1H), 3.74 (d, J=3.1 Hz, 1H), 3.22 (dd, J=2.6, 9.5 Hz, 1H); ^{13}C NMR (100.6 MHz, D_2O) δ 181.5 (C_q), 100.2 (CH), 95.7 (CH); MS (FAB, THG) 609 (M+Na), 587 (M+H).

Example B20: Preparation of compound B1.40.



13 **A4** **32**

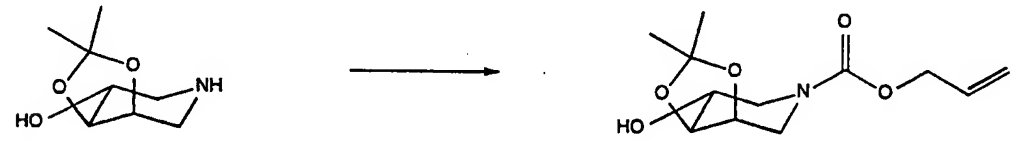
The coupling of the alcohol **13** with the triflate **A4** is carried out in accordance with Example B19 (preparation of compound **31**).



32 B1.40

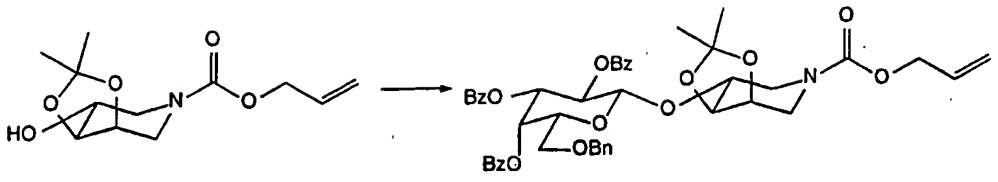
The hydrogenation of the benzyl ether and subsequent purification is carried out in accordance with Example B19 (preparation of compound **B1.39**): ^{1}H NMR (400 MHz, D_2O) δ 4.88 (d, J=4.1 Hz, 1H), 4.53 (q, J=6.7 Hz, 1H), 4.39 (d, J=7.7 Hz, 1H), 3.29 (dd, J=2.9, 9.8 Hz, 1H), 1.10 (d, J=6.8 Hz, 3H), 0.89 (d, J=6.8 Hz, 3H), 0.82 (d, J=6.8 Hz, 3H).

Example B21: Preparation of compound **B1.41**



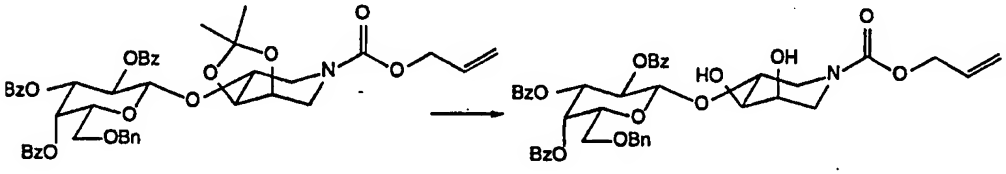
33 34

The hydroxypiperidine (6.0 g, 34.6 mmol, prepared from D-(–)-lyxose in accordance with Ichikawa and Igarashi [Ichikawa, Y., Igarashi, Y., Tetrahedron Letters 36:4585-4586 (1995)] and triethylamine (18.1 ml, 130 mmol) are dissolved in dry tetrahydrofuran (100 ml) and the solution is cooled to -10°C under an argon atmosphere. Allyl chloroformate (3.87 ml, 36.4°mmol) is slowly added over the course of one hour, a white suspension being formed. The reaction mixture is stirred at -10°C for a further hour, then 1M aqueous KH_2PO_4 solution (150 ml) is added, and the mixture is extracted three times with CH_2Cl_2. The combined organic phases are dried (Na_2SO_4) and concentrated in vacuo, resulting in a yellow oil (9 g). Purification by column chromatography on silica gel (hexane/ethyl acetate 1:1) results in the allyl carbamate **34** (7.66 g, 86 %).



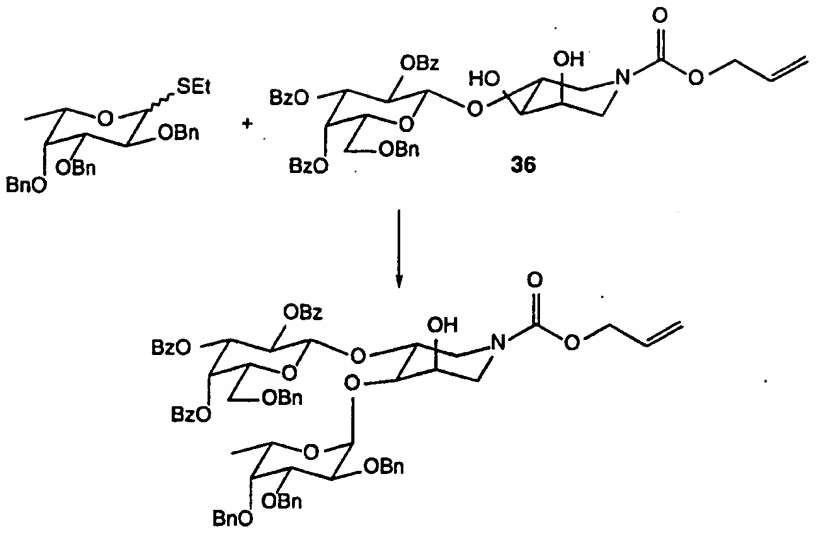
34 35

4Å molecular sieves (dried under high vacuum at 300°C, 15 g) are added to a solution of the acceptor **34** (7.66 g, 29.8 mmol) in dry CH_2Cl_2 (150 ml) under an argon atmosphere, and the suspension is stirred at room temperature for one hour. In parallel with this, a suspension of DMTST (15.4 g, 59.6 mmol) and 4Å molecular sieves (15 g) in dry CH_2Cl_2 (150 ml) is prepared under an argon atmosphere in a second round-bottom flask and is stirred for one hour. The DMTST mixture is then added in 4 portions over the course of a further hour to the solution of the acceptor, and the mixture is then stirred for one hour. The reaction mixture is filtered through Hyflo Super Cel® washing thoroughly with CH_2Cl_2. The filtrate is extracted by shaking with 10% aqueous $NaHCO_3$ solution, the aqueous phase is reextracted three times with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The remaining yellow oil (36 g) is purified by column chromatography on silica gel (gradient elution: hexane/ethyl acetate 3:1 to 3:2), resulting in the glycoside **35** (13.1 g, 54 %).



35 36

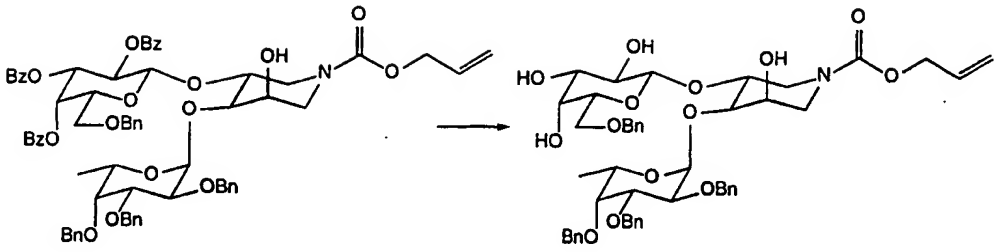
The acetonide **35** (13.1 g, 15.94 mmol) is dissolved in dioxane (140 ml) and, at room temperature 50 % aqueous trifluoroacetic acid (250 ml) is added. After 2 hours, the reaction mixture is concentrated under high vacuum, and the residue is purified by column chromatography on silica gel (ethyl acetate/hexane 2:1), resulting in the diol **36** (11, 23 g, 90 %).



36

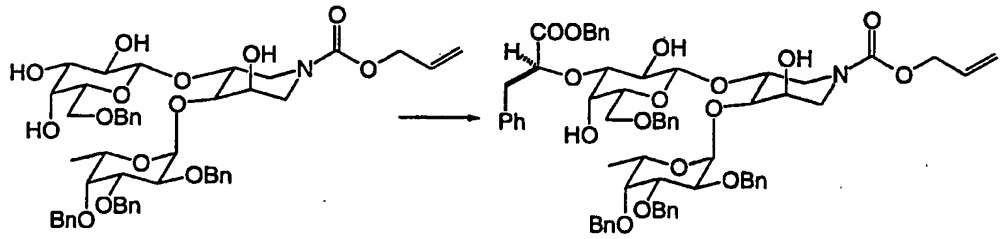
37

A mixture of the diol **36** (11.63 g, 14.88 mmol), tetra-*n*-butylammonium bromide (12.7 g, 39.4 mmol) and 4Å molecular sieves (dried under high vacuum at 300°C 22 g) is dried under high vacuum for 30 minutes and then, under an argon atmosphere, dry CH_2Cl_2 (62 ml) and dimethylformamide (36 ml) are added. The grey suspension is stirred at room temperature for 30 minutes. In parallel with this, a solution of ethyl -2,3,4-tri-*O*-benzyl-1-thio-L-fucopyranoside (7.48 g, 15.62 mmol, prepared by the method of Lonn [Lonn, H. Carbohydr. Res. 139:105-113 (1985)] in dry CH_2Cl_2 (49 ml) is prepared under an argon atmosphere in a second round-bottomed flask and, at 0°C, a bromine solution (2.85 g Br_2, 17,84 mmol) in CH_2Cl_2 (25 ml) is added. The red solution is stirred at 0°C for 30 minutes, and the excess bromine is destroyed by adding a few drops of cyclohexene. This solution is then added using a needle to the solution of the acceptor, and the reaction mixture is stirred at room temperature for 40 hours. The reaction mixture is then filtered through Hyflo Super Cel® and thoroughly washed with CH_2Cl_2, and the filtrate is washed with 10 % aqueous $NaHCO_3$ solution. The aqueous phase is reextracted three times with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The residue is purified by column chromatography on silica gel (ethyl acetate/hexane 35:65), with the required product **37** (7.85 g, 44 %) being eluted.



37 38

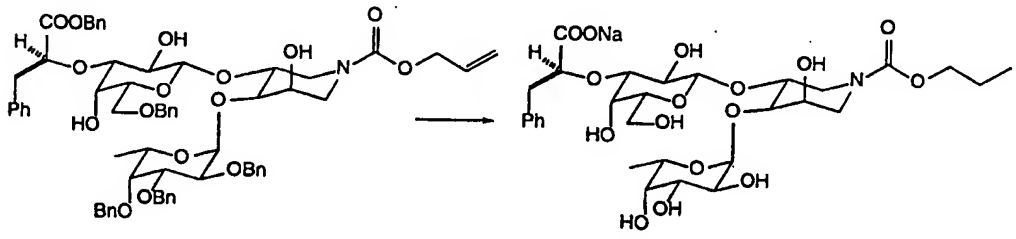
A solution of the ester **37** (2.4 g, 2.0 mmol) and sodium methoxide (0.11 g, 2.0 mmol) in methanol (48 ml) is stirred at room temperature for 8 hours. The clear colourless solution is then neutralized by adding a strongly acidic ion exchanger (Amberlyst15), then filtered through Hyflo Super Cel® and concentrated in vacuo. The oily residue is purified by column chromatography on silica gel (gradient elution: CH_2Cl_2/methanol 98:2 to 95:5), resulting in the triol **38** (1.72 g, 97 %).



38 39

A suspension of **38** (1.0 g, 1.13 mmol) and di-*n*-butyltin oxide (0.49 g, 1.98 mmol) in dry benzene (33 ml) is boiled under reflux in an argon atmosphere for 5 hours. The reaction mixture is concentrated in vacuo and dried under high vacuum for one hour. Then CsF (dried under high vacuum at 300°C for several hours, 0.43 g, 2.82 mmol) is added under an argon atmosphere, followed by dry 1,2-dimethoxyethane (7.4 ml) and a solution of benzyl *R*-3-phenyl-2-trifluoromethanesulfonyloxypropionate (2.6 g, 6.77 mmol) in dry 1,2-dimethoxyethane (4.9 ml). The reaction mixture is heated to 35 to 40°C and stirred at this temperature for 3 hours. Then a solution of 15% KF in 1M aqueous KH_2PO_4 solution (100 ml) is added, and the mixture is extracted three times with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The oily residue

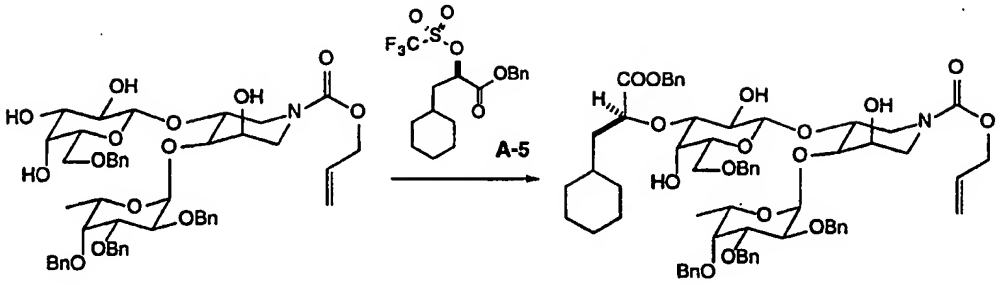
(3.2 g) is purified by column chromatography on silica gel (elution: toluene/ethyl acetate 70:30), resulting in the ether **39** (0.98 g, 78 %) as a colourless foam.



39 **B1.41**

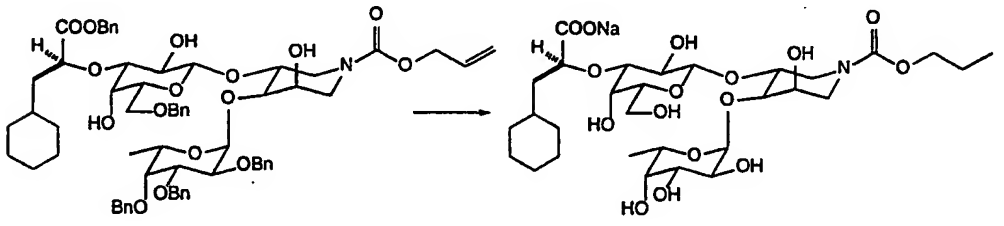
Dioxane (3.5 ml), water (1.7 ml) and glacial acetic acid (0.25 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.035 g) and the benzyl ether **39** (0.038 g, 0.034 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 24 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm) washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: H_2O/methanol 65:35 to 55:45), resulting in the target molecule **B1.41** (0.014 g, 59 %) as a fluffy white solid (after lyophilization): ^1H NMR (500 MHz, D_2O, +50°C) δ 7.58 - 7.53 (m, 4H), 7.51 - 7.46 (m, 1H), 5.22 (d, J=4.0 Hz, 1H), 4.57 (d, J=7.6 Hz, 1H), 4.56 (q, J=6.4 Hz, 1H), 4.33 (dd, J=4.2, 8.6 Hz, 1H), 4.30 (dt, J=6.3, 3.2 Hz, 1H), 3.66 (dd, J=8.0, 9.4 Hz, 1H), 3.59 (dd, J=3.0, 13.8 Hz, 1H), 3.33 (dd, J=4.2, 14.0 Hz, 1H), 3.13 (dd, J=9.0, 14.0 Hz, 1H), 1.82 (sex, J=6.9 Hz, 2H), 1.36 (d, J=6.4 Hz, 3H), 1.10 (t, J=7.5 Hz, 3H); MS (FAB, NBA) 720 (M+Na), 698 (M+H).

Example B22: Preparation of compound **B1.42**.



38 **40**

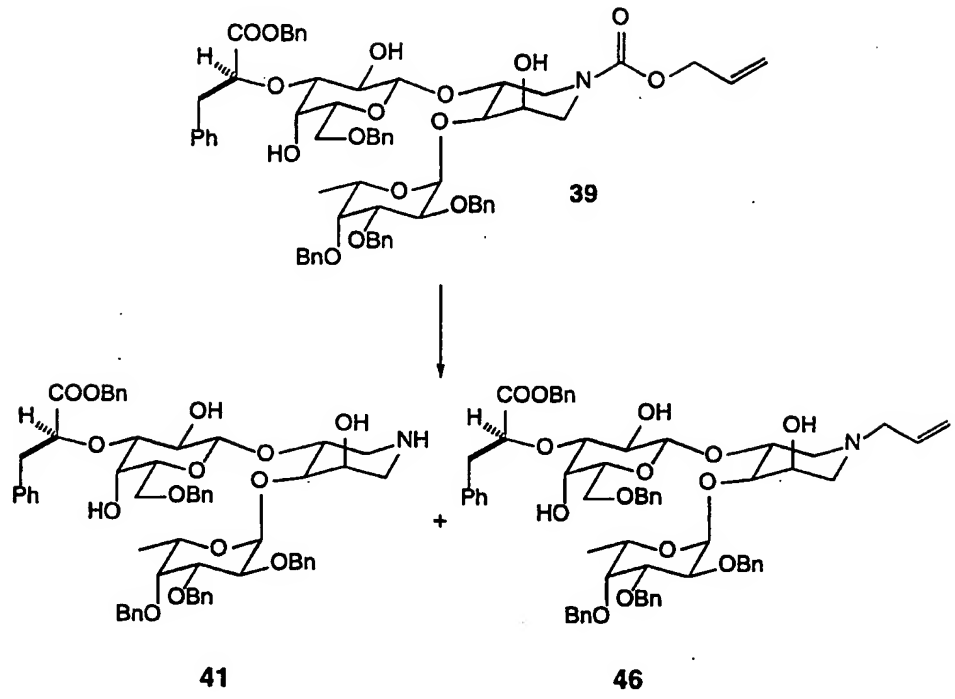
A suspension of **38** (0.65 g, 0.73 mmol) and di-*n*-butyltin oxide (0.32 g, 1.28 mmol) in dry benzene (22 ml) is boiled under reflux in an argon atmosphere for 16 hours. The reaction mixture is concentrated in vacuo and dried under high vacuum for one hour. Then CsF (dried under high vacuum at 300°C for several hours, 0.28 g, 1.83 mmol) is added under an argon atmosphere, followed by dry 1,2-dimethoxyethane (4.0 ml) and a solution of the triflate **A5** (1.74 g, 4.4 mmol) in dry 1,2-dimethoxyethane (2.7 ml). The reaction mixture is heated to 35 to 40°C and stirred at this temperature for 3 hours. Then a solution of 15% KF in 1M aqueous KH_2PO_4 solution (100 mL), is added, and the mixture is extracted three times with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The oily residue (2.6 g) is purified by column chromatography on silica gel (elution: toluene/ethyl acetate 3:1, then CH_2Cl_2/methanol 19:1) resulting in the ether **40** (0.33 g, 40 %) as a colourless foam, and partial recovery of the precursor **38** (0.167 g, 26 %).



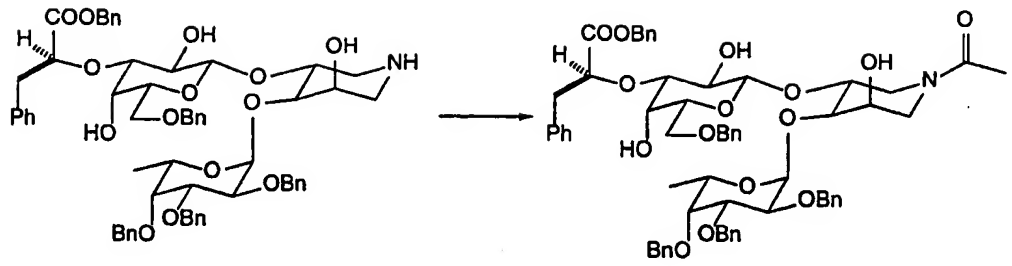
40 **B1.42**

Dioxane (1.2 ml), water (0.6 ml) and glacial acetic acid (0.3 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.025 g) and the benzyl ether **40** (0.036 g, 0.032 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 8 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm) washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm , column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: H_2O/methanol 1:1), resulting in the target molecule **B1.42** (0.009 g, 41 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 5.09 (d, J=3.7 Hz, 1H), 4.58 - 4.46 (m, 2H), 3.94 (d, J=2.2 Hz, 1H), 3.58 (t, J=8.4 Hz, 1H), 3.43 (dd, J=1.8, 9.5 Hz, 1H), 1.83 (d, J=12.2 Hz, 1H), 1.23 (d, J=6.7 Hz, 3H), 0.95 (t, J=7.6 Hz, 3H); ^{13}C NMR (100.6 MHz, D_2O) δ 183.0 (C_q), 101.6 (CH), 98.0 (CH); MS (FAB, THG) 704 (M+H).

Example B23: Preparation of compound **B1.43**.

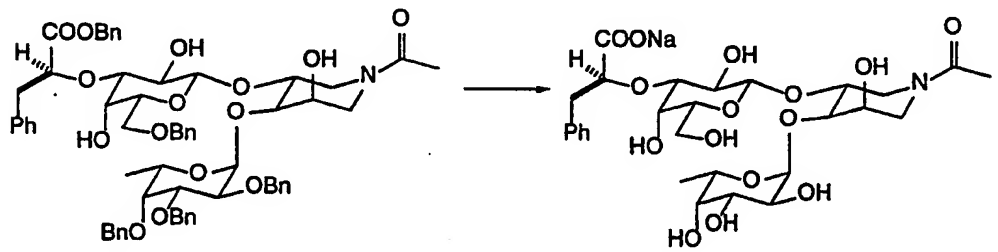


Morpholine (1.1 ml) and $Pd(PPh_3)_4$ (0.071 g, 0.062 mmol) are added to a solution of the allyl carbamate **39** (0.695 g, 0.618 mmol) in tetrahydrofuran (8.5 ml). After exactly 15 minutes the solution is concentrated and the residue is dried under high vacuum for one hour. Purification of the residue by column chromatography on silica gel (eluent: CH_2Cl_2/ methanol 98:2, contains 0.3 % concentrated aqueous ammonia solution) gives initially the less polar allylamine **46** (0.24 g, 36 %) followed by the more polar piperidine **41** (0.39 g, 60 %).



41 42

Pyridine (5 µl, 0.06 mmol) and acetic anhydride (1,8 µ l, 0.04 mmol) are added under an argon atmosphere to a solution of the piperidine derivative **41** (0.035 g, 0.0336 mmol) in dry CH_2Cl_2 (0.6 ml) at 0°C. The solution is stirred at 0°C for 45 minutes and then washed with 5% aqueous $NaHCO_3$ solution, and the aqueous phase is reextracted three times with CH_2Cl_2.The combined organic phases are dried with Na_2SO_4, filtered and concentrated in vacuo. The residue (0.05 g) is purified by column chromatography on silica gel (eluent: ethyl acetate/hexane 4:1), resulting in the acetylpiperidine **42** (0.033 g, 91 %) as a colourless foam.

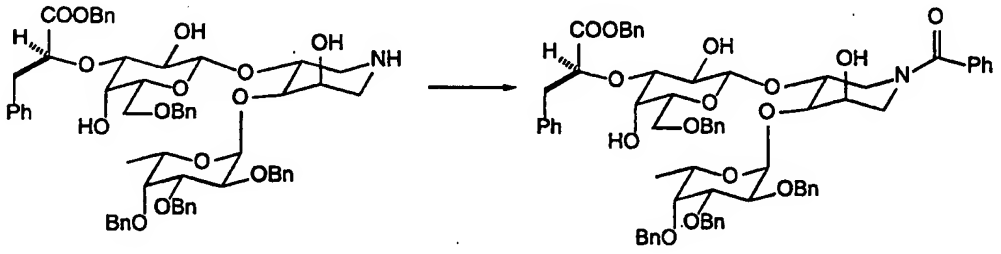


42 B1.43

Dioxane (1.4 ml), water (0.7 ml) and glacial acetic acid (0.35 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.03 g) and the benzyl ether **42** (0.04 g, 0.037 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 48 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column

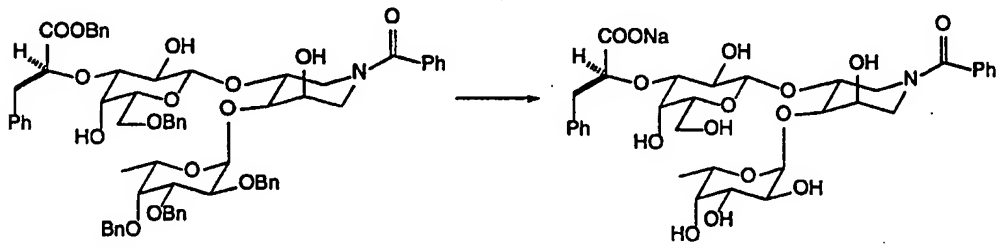
(Na⁺form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: methanol/H_2O 2:3 via 1:1 to 3:2), resulting in the target molecule **B1.43** (0.014 g, 64 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 7.22 - 7.06 (m, 5H), 4.86 (m, 1H), 1.95 (s, 3H), 0.98 (d, J=6.7 Hz, 3H); MS (FAB, THG) 654 (M+H), 632 (M+2H-Na).

Example B24: Preparation of compound **B1.44**.



41 **43**

Compound **43** is prepared from the piperidine **41** (0.02 g, 0.019 mmol) and benzoyl chloride (2.5 µl, 0.021 mmol) in analogy to a method for the acetylpiperidine **42** (Example B23). The yield is 0.02 g (90 %).

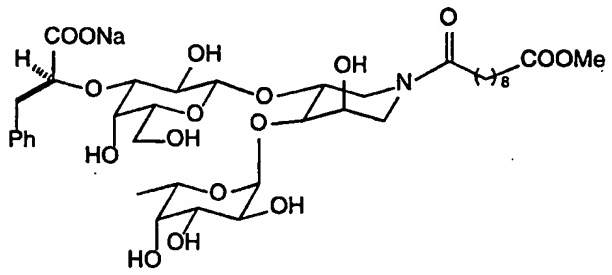


43 **B1.44**

The target compound **B1.44** is prepared by hydrogenation of the benzyl ether **43** (0.042 g, 0.0367 mmol) and subsequent purification in analogy to the acetyl derivative **B1.43.** The

product results after lyophilization as a fluffy white solid. Yield: 0.015 g (57 %): MS (FAB, THG) 716 (M+H), 694 (M+2H-Na).

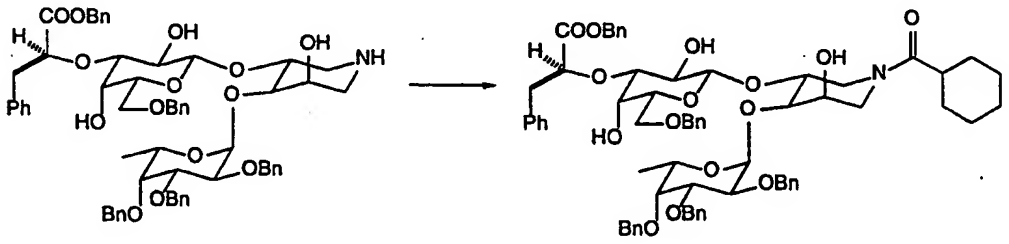
Example B25: Preparation of compound **B1.45**.



B1.45

The target compound **B1.45** is prepared in analogy to Example 23 (preparation of compound **B1.43**) from the piperidine derivative **41**: ^{1}H NMR (400 MHz, D_2O) δ 7.28 - 7.13 (m, 5H), 4.95 (m, 1H), 4.37 - 4.23 (m, 2H), 3.56 (s, 3H), 3.04 (m, 1H), 2.84 (m, 1H), 2.26 (t, J=7.6 Hz, 2H), 1.08 (d, J=7.4 Hz, 3H); MS (FAB, THG) 810 (M+H).

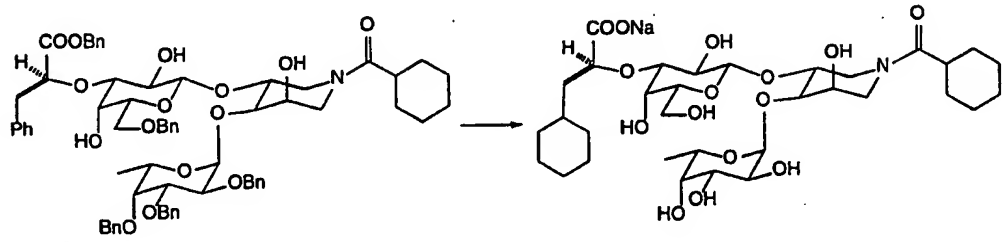
Example B26: Preparation of compound **B1.46**.



41 **45**

Pyridine (4 µl, 0.05 mmol) and cyclohexanecarbonyl chloride (7.2 µl, 0.05 mmol) are added at 0°C to a solution of the piperidine derivative **41** (0.04 g, 0.038 mmol) in dry CH_2Cl_2 (0.7 ml). After 20 minutes, the reaction mixture is washed with 10 % aqueous $NaHCO_3$ solution, and the aqueous phase is reextracted three times with CH_2Cl_2. The combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. Purification by

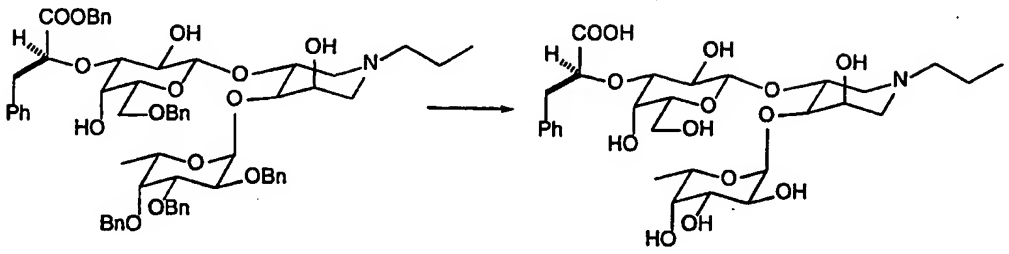
column chromatography as the crude product (0.09 g) on silica gel (eluent: hexane/ethyl acetate 1:1) gives the amide **45** (0.03 g, 68 %).



45 **B1.46**

Dioxane (1.1 ml), water (0.55 ml) and glacial acetic acid (0.27 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.05 g) and the benzyl ether **45** (0.029 g, 0.025 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 24 hours. Then, for hydrogenation of the aromatic ring, 5% Rh/C (0.02 g) is added and hydrogenation is continued for 24 hours. The reaction mixture is filtered through a cellulose filter (pore size 45 µm), the filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 60:40), resulting in the target molecule **B1.46** (0.012 g, 64 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 5.04 (m, 1H), 4.48 (m, 1H), 4.45 - 4.32 (m, 1H), 2.72 (m, 1H), 1.17 (d, J=5.8 Hz, 3H); MS (FAB, THG) 728 (M+H), 706 (M+2H-Na).

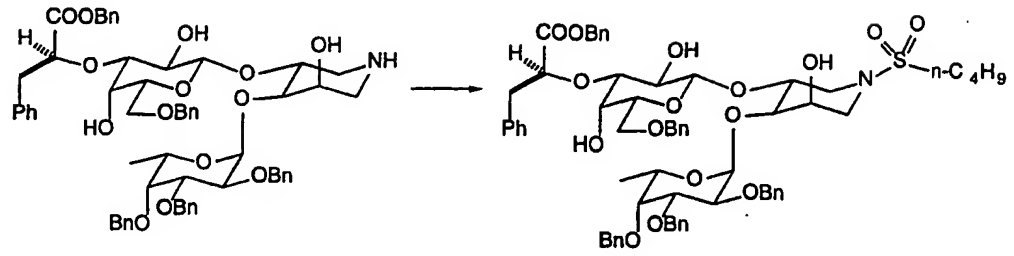
Example B27: Preparation of compound **B1.47**.



46 **B1.47**

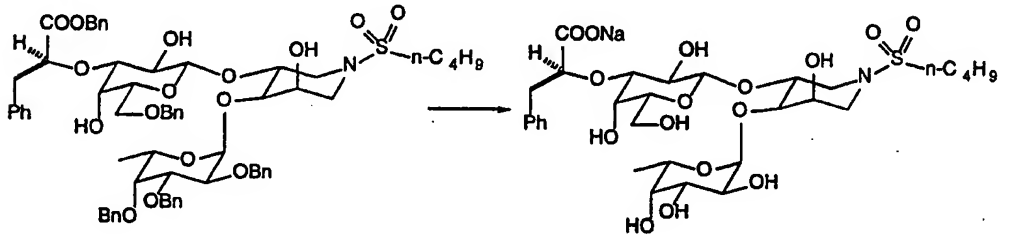
Dioxane (1.4 ml), water (0.7 ml) and glacial acetic acid (0.35 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.03 g) and the benzyl ether **46** (0.042 g, 0.039 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 16 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up in water and concentrated again several times in order to remove excess acetic acid. The crude product (0.014 g) is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 1:3) resulting in the target molecule **B1.47** (0.009 g, 36 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 7.10 - 7.02 (m, 4H), 7.01 - 6.94 (m, 1H), 4.80 (br s, 1H), 4.10 (d, J=7.0 Hz, 1H), 3.84 (dd, J=4.7, 8.5 Hz, 1H), 3.20 (t, J=8.7 Hz, 1H), 2.97 (dd, J=3.3, 9.7 Hz, 1H), 2.83 (dd, J=4.7, 13.1 Hz, 1H), 2.63 (dd, J=8.5, 13.1 Hz, 1H), 0.87 (d, J=7.0 Hz, 3H), 0.63 (t, J=7.3 Hz, 3H); MS (FAB, THG) 654 (M+Na), 632 (M+H).

Example B28: Preparation of compound **B1.48**.



41 **47**

Triethylamine (7 µl, 0.05 mmol) and *n*-butanesulfonyl chloride (3.7 µl, 0.029 mmol) are added at 0°C to a solution of the piperidine **41** (0.025 g, 0.024 mmol) in CH_2Cl_2 (0.3 ml). After 45 minutes, the reaction mixture is washed with 10 % aqueous $NaHCO_3$ solution, and the aqueous phase is reextracted three times with CH_2Cl_2. The combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The crude product is purified by column chromatography on silica gel (eluent: hexane/ethyl acetate 60:40), resulting in the sulfonamide **47** (0.022 g, 79 %).

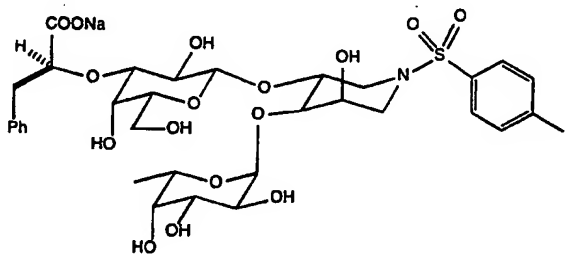


47 **B1.48**

Dioxane (1.0 ml), water (0.5 ml) and glacial acetic acid (0.25 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.013 g) and the benzyl ether **47** (0.027 g, 0.023 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 24 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic

acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: methanol/H_2O 35:65 to 45:55), resulting in the target molecule **B1.48** (0.011 g, 65 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 7.51 - 7.35 (m, 5H), 5.15 (d, J=3.4 Hz, 1H), 4.54 (q, J=6.2 Hz, 1H), 4.51 (d, J=8.0 Hz, 1H); 4.03 (dd, J=2.8, 10.4 Hz, 1H), 3.59 (t, J=8.9 Hz, 1H), 3.23 (dd, J=4.8, 13.4 Hz, 1H), 3.05 (dd, J=8.6, 13.4 Hz, 1H), 1.84 (pen, J=7.6 Hz, 2H), 1.54 (sex, J=7.3 Hz, 2H), 1.27 (d, J=6.6 Hz, 3H), 1.02 (t, J=7.5 Hz, 3H); MS (FAB, THG) 732 (M+H).

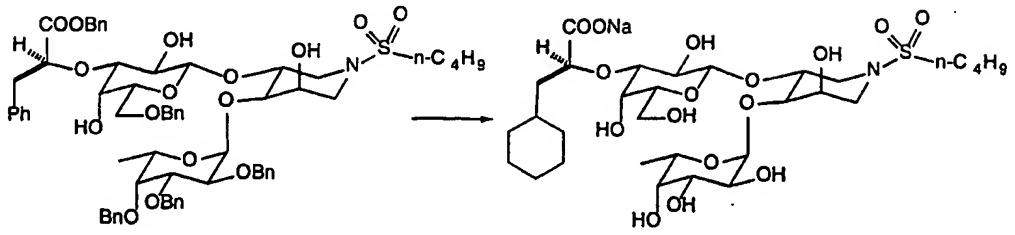
Example B29: Preparation of compound **B1.49**.



B1.49

The target compound **B1.49** is prepared in analogy to Example B28 (preparation of compound **B1.48**) starting from the piperidine derivative **41** and *p*-toluenesulfonyl chloride: ^1H NMR (400 MHz, D_2O) δ 7.56 (d, J=7.2 Hz, 2H), 7.33 (d, J=7.2 Hz, 2H), 7.28 - 7.11 (m, 5H), 4.81 (d, J=3.4 Hz, 1H), 4.22 (d, J=7,9 Hz, 1H), 3.75 (d, J=2.4 Hz, 1H), 3.65 (dd, J=2.4, 10.2 Hz, 1H), 3.41 (t, J=5.7 Hz, 1H), 3.32 (t, J=8.7 Hz, 1H), 3.13 (dd, J=2.5, 9.3 Hz, 1H), 3.00 (dd, J=4.0, 13.6 Hz, 1H), 2.81 (dd, J=8.9, 13.6 Hz, 1H), 2.67 (br s, 1H), 2.29 (s, 3H), 0.95 (d, J=7.1 Hz, 3H); MS (FAB, THG) 788 (M+Na), 766 (M+H).

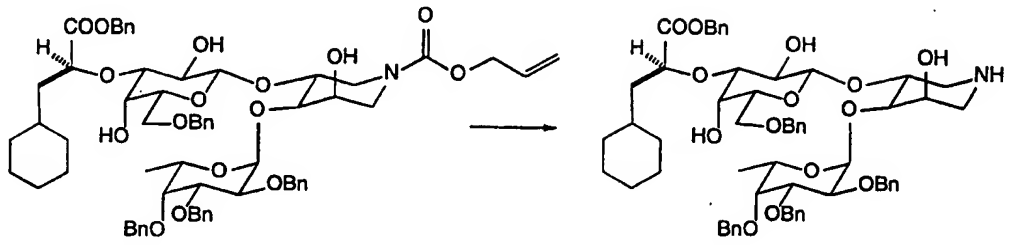
Example B30: Preparation of compound **B1.50**.



47 **B1.50**

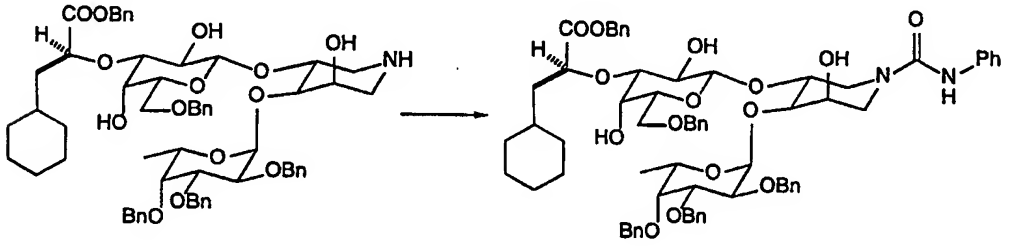
Dioxane (1.5 ml), water (0.75 ml) and glacial acetic acid (0.38 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.02 g) and the benzyl ether **47** (0.041 g, 0.035 mmol) The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 16 hours. Then, to hydrogenate the aromatic ring, 5% Rh/C (0.025 g) is added, and hydrogenation is continued for 16 hours. The reaction mixture is filtered through a cellulose filter (pore size 45 µm), the filtrate is concentrated in vacuo, and the residue is taken up in water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: methanol/H_2O 40:60 to 50:50), resulting in the target molecule **B1.50** (0.021 g, 82 %) as a fluffy white solid (after lyophilization). ^1H NMR (400 MHz, D_2O) δ 4.97 (d, J=3.7 Hz, 1H), 4.41 (d, J=7.7 Hz, 1H), 4.36 (q, J=6.7 Hz, 1H), 3.81 (d, J=2.6 Hz, 1H), 3.76 (dd, J=2.4, 7.3 Hz, 1H), 3.55 (dd, J=4.4, 7.2 Hz, 1H), 3.30 (dd, J=2.7, 9.7 Hz, 1H), 1.34 (sex, J=7.4 Hz, 2H), 1.10 (d, J=6.7 Hz, 3H), 0.81 (t, J=7.5 Hz, 3H); MS (FAB, THG) 738 (M+H), 716 (M+2H-Na).

Example B31: Preparation of compound **B1.51**.



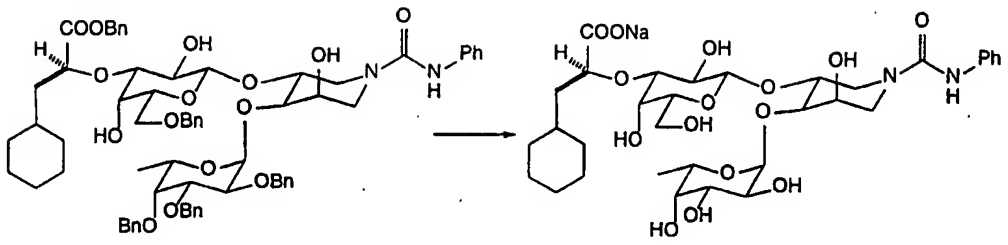
40 **49**

Morpholine (0.37 ml) and $Pd(PPh_3)_4$ (0.025 g, 0.021 mmol) are added to a solution of the allyl carbamate **40** (0.24 g, 0.212 mmol) in tetrahydrofuran (2.9 ml). After exactly 15 minutes, the solution is concentrated and the residue is dried under high vacuum for one hour. Purification of the residue (0.38 g) by column chromatography on silica gel (eluent: CH_2Cl_2/methanol 19:1, contains 0.3 % concentrated aqueous ammonia solution) gives the piperidine derivative **49** (0.17 g, 76 %).



49 **50**

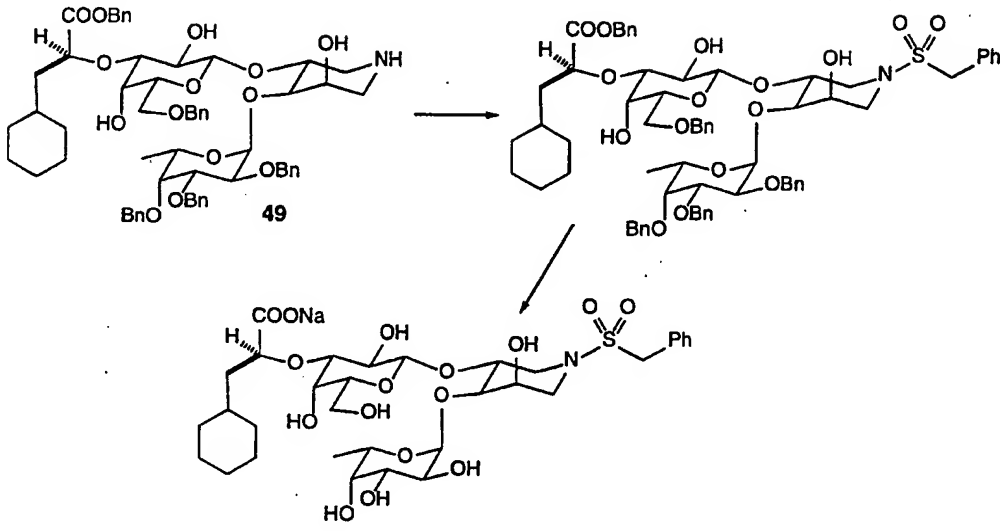
Phenyl isocyanate (4.6 µl, 0.042 mmol) and diisopropylethylamine (8.5 µl, 0.05 mmol) are added at 0°C to a solution of the piperidine derivative **49** (0.04 g, 0.038 mmol) in CH_2Cl_2 (0.6 ml). After 90 minutes, the reaction mixture is washed with 1 M aqueous KH_2PO_4 solution and the aqueous phase is reextracted three times with CH_2Cl_2. The combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. Purification of the crude product (0.047 g) by column chromatography on silica gel (eluent: hexane/ethyl acetate 58:42) provides the urea derivative **50** (0.035 g, 78 %).



50 B1.51

Dioxane (1.3 ml), water (0.65 ml) and glacial acetic acid (0.33 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.018 g) and the benzyl ether **50** (0.036 g, 0.031 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 16 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. A solution of the residue in water is passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The clear filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 1:1), resulting in the target molecule **B1.51** (0.018 g, 80 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 7.14 (t, J=7.9 Hz, 2H), 7.02 (d, J=8.2 Hz, 2H), 6.95 (t, J=7.7 Hz, 1H), 4.87 (d, J=4.0 Hz, 1H), 4.30 (d, J=7.4 Hz, 1H), 4.23 (q, J=6.6 Hz, 1H), 3.66 (d, J=2.8 Hz, 1H), 3.42 (dd, J=4.4, 7.7 Hz, 1H), 3.16 (dd, J=2.6, 9.5 Hz, 1H), 1.00 (d, J=6.6 Hz, 3H); MS (FAB, THG) 737 (M+H), 715 (M+2H-Na).

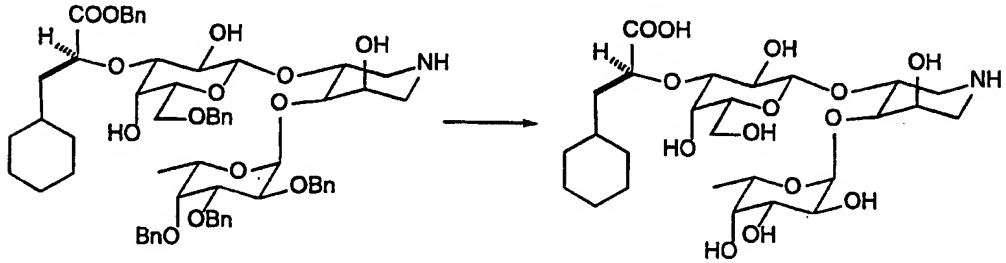
Example B32: Preparation of compound **B1.52**.



B1.52

The piperidine derivative **49** is converted in analogy to Example B28 (preparation of compound **B1.48**) using phenylmethanesulfonyl chloride as reagent into the target compound **B1.52:** ^{1}H NMR (400 MHz, D_2O) δ 7.50 (m, 5H), 5.02 (d, J=3.5 Hz, 1H), 4.61 (d, J=13.7 Hz, 1H), 4.54 (d, J=13.7 Hz, 1H), 4.32 (d, J=8.0 Hz, 1H), 3.62 (t, J=6.0 Hz, 1H), 3.52 (dd, J=7.7, 8.4 Hz, 1H), 3.36 (dd, J=3.2, 9.6 Hz, 1H), 3.22 (br d, J=12.6 Hz, 1H), 1.17 (d, J=6.5 Hz, 3H); MS (FAB, THG) 772 (M+H), 750 (M+2H-Na).

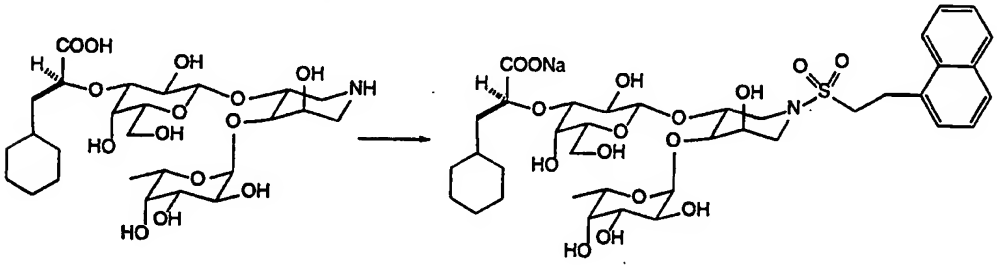
Example B33: Preparation of compound **B1.53**.



49 **B1.53**

Dioxane (3.7 ml), water (1.8 ml) and glacial acetic acid (0.9 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.05 g) and the benzyl ether **49** (0.09 g, 0.086 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 48 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. The crude product (0.044 g) is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detektion at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, gradient elution: methanol/H_2O 30:70 to 50:50), resulting in the target molecule **B1.53** (0.04 g, 78 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 5.04 (d, J=4.2 Hz, 1H), 4.43 (d, J=7.6 Hz, 1H), 4.27 (m, 2H), 4.20 (q, J=6.5 Hz, 1H), 4.02 (dd, J=2.6, 6.6 Hz, 1H), 3.51 (dd, J=7.8, 9.5 Hz, 1H), 1.12 (d, J=6.2 Hz, 3H); MS (FAB, THG) 618 (M+Na), 596 (M+H).

Example B34: Preparation of compound **B1.54**.

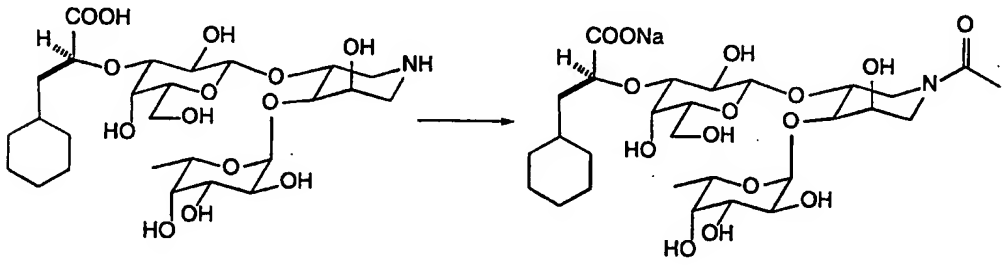


B1.53 **B1.54**

A 1 M solution of 2-(1-naphthyl)ethanesulfonyl chloride in toluene (46 µl) is added at room temperature to a solution of the piperidine derivative **B1.53** (0.025 g, 0.042 mmol) in 1M aqueous $NaHCO_3$ solution (0.22 ml). The mixture is vigorously stirred for 22 hours and then concentrated in vacuo and dried under high vacuum for 15 minutes. The crude product is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse

phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 7:3), resulting in the target molecule **B1.54** (0.011 g, 31 %) as a fluffy white solid (after lyophilization): ^{1}H NMR (400 MHz, D_2O) δ 7.72 (d, J=8.8 Hz, 1H), 7.54 (d, J=8.8 Hz, 1H), 7.44 (d, J=8.6 Hz, 1H), 7.28 (t, J=7.2 Hz, 1H), 7.22 (t, J=7.2 Hz, 1H), 7.14 (t, J=7.2 Hz, 1H), 7.08 (d, J=8.7 Hz, 1H), 4.91 (d, J=4.1 Hz, 1H), 4.20 (d, J=7.0 Hz, 1H), 3.99 (br s, 1H), 3.90 (br s, 1H), 1.09 (d, J=6.3 Hz, 3H); MS (FAB, THG) 858 (M+Na), 836 (M+H).

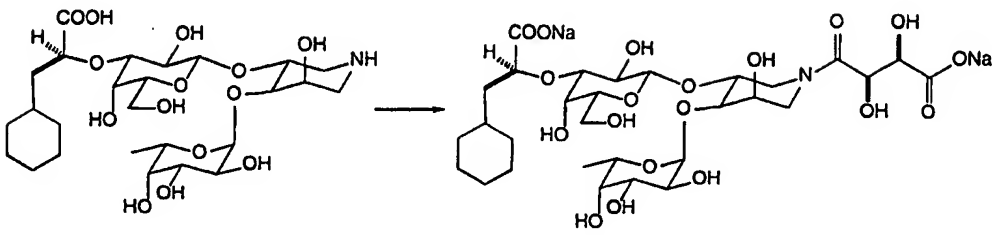
Example B35: Preparation of compound **B1.55**.



B1.53 **B1.55**

A 0.5 M solution of acetic anhydride in toluene is added in small portions (50 to 100 µl) at room temperature to a solution of the piperidine derivative **B1.53** (0.035 g, 0.059 mmol) in 1 M aqueous $NaHCO_3$ solution (0.5 ml) until all the precursor is consumed (test by thin-layer chromatography: silica gel TLC plates, mobile phase: *n*-butanol/ water/acetone/glacial acetic acid/NH_4OH 70:60:50:18:1.5). The reaction is complete after about one hour, and the mixture is concentrated in vacuo and dried under high vacuum for 15 minutes. The crude product is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 3:7), resulting in the target molecule **B1.55** (0.026 g, 67 %) as a fluffy white solid (after lyophilization): ^{1}H NMR (400 MHz, D_2O) δ 5.01 (d, J=4.2 Hz, 0.5H), 4.99 (d, J=4.2 Hz, 0.5H), 4.44 (d, J=7.3 Hz, 1H), 4.32 (q, J=6.6 Hz, 0.5H), 3.14 (dd, J=8.0, 12.9 Hz, 0.5H), 2.10 (s, 1.5H), 2.08 (s, 1.5H), 1.13 (d, J=6.6 Hz, 3H).

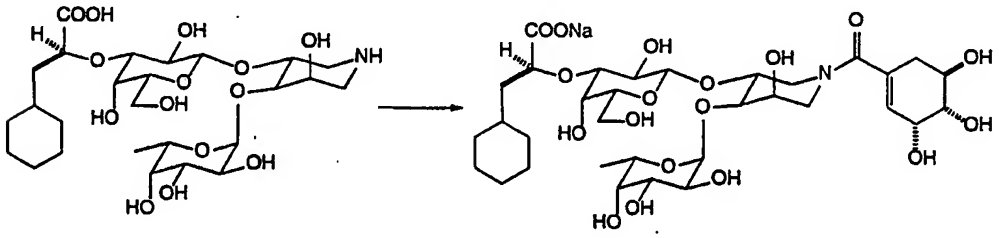
Example B36: Preparation of compound **B1.56**.



B1.53 **B1.56**

A 1.5 M solution (+)-di-O-acetyl-L-tartaric anhydride in 1,4-dioxane is added in small portions (50 to 100 µl) at room temperature to a solution of the piperidine derivative **B1.53** (0.03 g, 0.05 mmol) in 1 M aqueous NaOH solution (0.15 ml) until all the precursor is consumed (test by thin-layer chromatography: silica gel TLC plates, mobile phase: *n*-butanol/water/acetone/glacial acetic acid/NH_4OH 70:60:50:18:1.5). The mixture is kept basic throughout the reaction by periodic addition of 1 M NaOH solution. The starting material is consumed after about two hours and then a further 1 M sodium hydroxide solution (0.13 ml) is added and the mixture is heated to 40°C in order to hydrolyse the ester groups. After one hour, the mixture is concentrated in vacuo and dried under high vacuum for 15 minutes. The crude product is purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 1:9), resulting in the target molecule **B1.56** (0.020 g, 52 %) as a fluffy white solid (after lyophilization): MS (FAB, THG) 794 (M+Na), 772 (M+H), 750 (M+2H-Na).

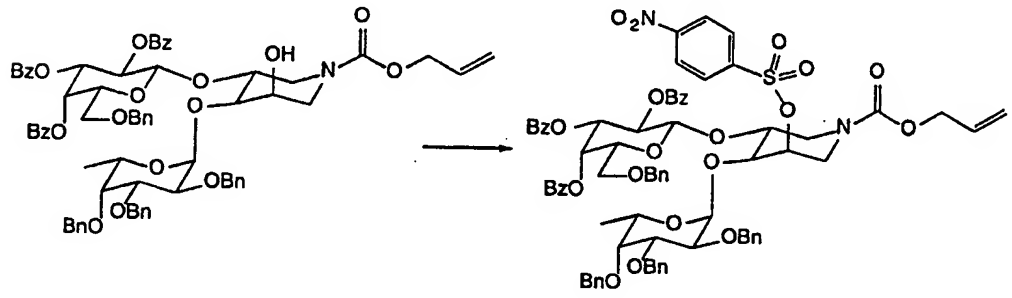
Example B37: Preparation of compound **B1.57**.



B1.53 **B1.57**

N,N-Diisopropylcarbodiimide (11.7 µl, 0.075 mmol) is added at 0°C to a solution of shikimic acid (0.013 g, 0.075 mmol) and 1-hydroxybenzotriazole (0.01 g, 0.075 mmol) in dry N,N-dimethylformamide (0.37 ml), and the mixture is then stirred for 30 minutes. The mixture is then warmed to room temperature and the piperidine derivative **B1.53** (0.015 g, 0.025 mmol) is added. After 3 hours, 10 % aqueous $NaHCO_3$ solution is added (0.15 ml), and the reaction mixture is stirred for a further 20 minutes and then concentrated under high vacuum. The residue is taken up in water, filtered through a cellulose filter (pore size 45 µm) and then passed through a Dowex50 ion exchange column (Na^+ form, diameter of the column 0.9 cm, length 3.5 cm), washing with deionized water. The filtrate is concentrated in vacuo and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 1:9), resulting in the target molecule **B1.57** (0.007 g, 33 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 5.8 (br s, 1H), 4.94 (m, 1H), 2.55 (m, 1H), 2.10 (m, 1H), 1.07 (d, J=6.0 Hz, 3H); MS (FAB, THG) 796 (M+Na), 774 (M+H).

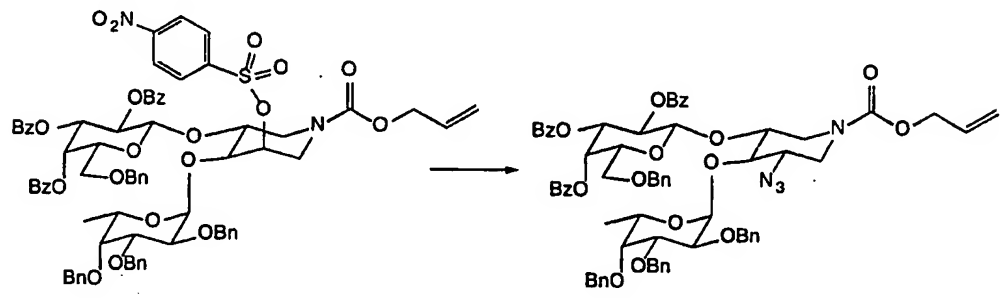
Example B38: Preparation of compound **B1.58**.



37 **52**

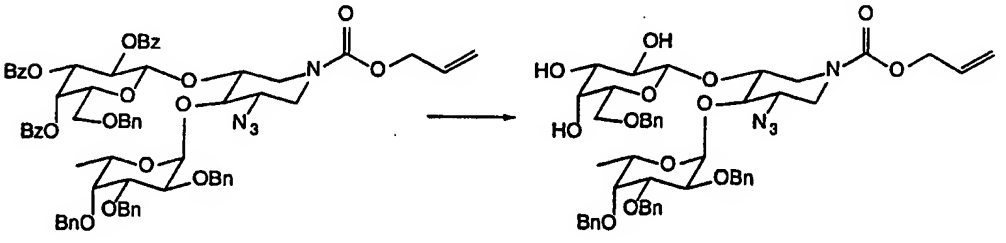
N,N-Dimethylaminopyridine (1.03 g, 8.44 mmol) and *p*-nitrobenzenesulfonyl chloride (1.65 g, 7.44 mmol) are added at room temperature to a solution of the alcohol **37** (6.11 g, 5.1 mmol) in CH_2Cl_2 (35 ml). After 52 hours, the reaction mixture is washed with 10 % aqueous $NaHCO_3$ solution, and the aqueous phase is reextracted three times with CH_2Cl_2.The combined organic phases are dried (Na_2SO_4), filtered and concentrated in

vacuo. The crude product (10 g) is purified by column chromatography on silica gel (eluent: ethyl acetate/hexane 35:65), resulting in the nosylate **52** (6.58 g, 93 %).



52 **53**

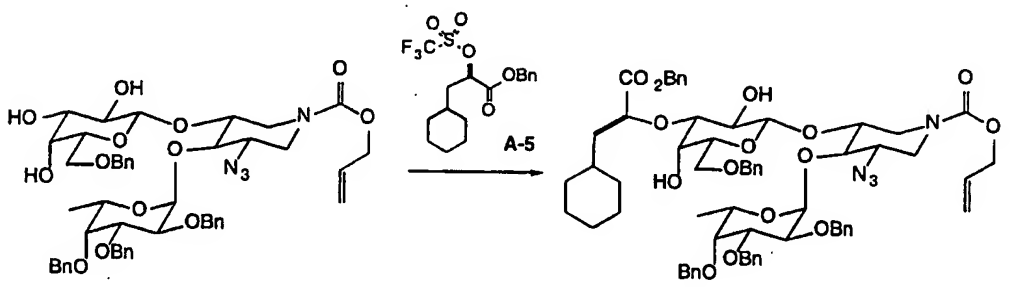
A solution of the nosylate **52** (7.78 g, 5.62 mmol) and dry LiN_3 (0.99 g, 20.21 mmol) in dry N,N-dimethylformamide (50 ml) is heated to 50-60°C under an argon atmosphere. After 16 hours, the solvent is removed under high vacuum, and the residue is taken up in CH_2Cl_2 and washed with 10 % aqueous $NaHCO_3$ solution. The aqueous phase is extracted three times with CH_2Cl_2 and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The crude product is purified by column chromatography on silica gel (eluent: ethyl acetate/hexane 30:70), with elution first of the required azide **53** (4.22 g, 61 %), followed by the alcohol **37** (2.5 g).



53 **54**

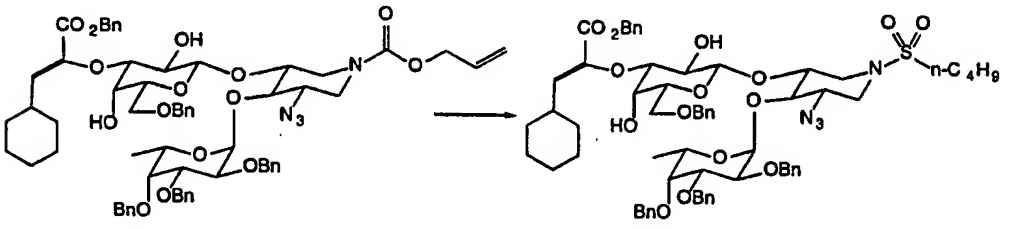
A solution of the tribenzoate **53** (4.22 g, 3.45 mmol) and sodium methoxide (0.55 g, 10.2 mmol) in methanol (110 ml) and dioxane (5 ml) is stirred at room temperature for 2.5 hours. The pH of the reaction mixture is then made neutral by adding strongly acidic ion exchanger (Amberlyst15, H^+ Form), the suspension is filtered, and the filtrate is concentra-

ted in vacuo. The crude product (4.5 g) is purified by column chromatography on silica gel (eluent: CH_2Cl_2/methanol 19:1) to give the triol **54** (2.89 g, 92 %).



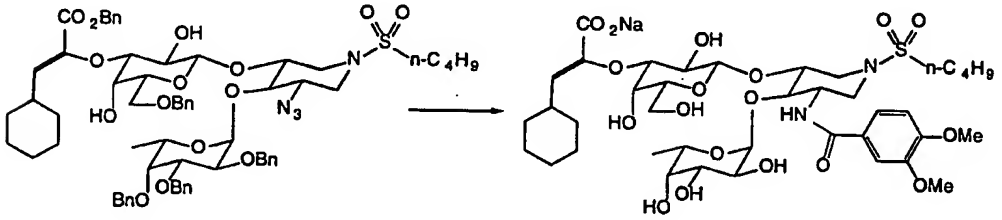
54 **55**

A suspension of **54** (2.89 g, 3.17 mmol) and di-*n*-butyltin oxide (1.56 g, 6.27 mmol) in dry benzene (95 ml) is boiled under reflux in an argon atmosphere for 16 hours. The reaction mixture is concentrated in vacuo and dried under high vacuum for one hour. Then CsF (dried under high vacuum at 300°C for several hours, 1.2 g, 7.9 mmol) is added under an argon atmosphere, followed by dry 1,2-dimethoxyethane (80 ml) and a solution of the triflate **A5** (6.3 g, 15.97 mmol) in dry 1,2-dimethoxyethane (50 ml). The reaction mixture is heated to 35 to 40°C and stirred at this temperature for 3 hours. The mixture is then washed with a solution of 15% KF in 1M aqueous KH_2PO_4 (150 ml) and the aqueous phase is extracted three times with CH_2Cl_2, and the combined organic phases are dried (Na_2SO_4), filtered and concentrated in vacuo. The oily residue (10.9 g) is purified by column chromatography on silica gel (elution: toluene/ethyl acetate 4:1, then CH_2Cl_2/methanol 19:1 to recover the precursor), resulting in the ether **55** (1.94 g, 53 %) as a colourless foam and partial recovery of the precursor (1.1 g, 26 %).



55 **56**

Morpholine (215 µl) and $Pd(PPh_3)_4$ (0.015 g, 0.013 mmol) are added under an argon atmosphere to a solution of the allyl carbamate **55** (0.15 g, 0.13 mmol) in tetrahydrofuran (1.7 ml). After exactly 15 minutes, the solution is concentrated and the residue is dried under high vacuum for one hour. The crude product is purified on a short silica gel column (eluent: CH_2Cl_2/methanol 19:1, contains 0.3 % concentrated aqueous ammonia solution) and then dried under high vacuum for one hour. The residue is then taken up in dry CH_2Cl_2 (1.7 ml), the solution is cooled to 0°C, and triethylamine (43 µl, 0.31 mmol) and *n*-butanesulfonyl chloride (18 µl, 0.14 mmol) are added. After 15 minutes, the reaction mixture is warmed to room temperature and washed with 10 % aqueous $NaHCO_3$ solution. The aqueous phase is reextracted three times with CH_2Cl_2, and the organic phases are combined, dried (Na_2SO_4), filtered and concentrated in vacuo. Purification of the crude product by column chromatography on silica gel (eluent: ethyl acetate/hexane 30:70) gives the sulfonamide **56** (0.12 g, 77 %).

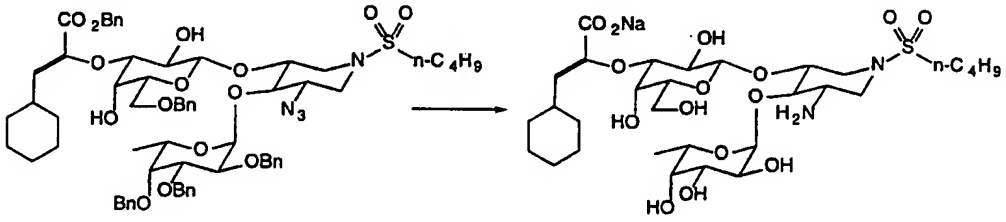


56 **B1.58**

Dioxane (1.2 ml), water (0.6 ml) and glacial acetic acid (0.25 ml) are added to a mixture of $Pd(OH)_2$/C (Pearlman catalyst, Pd content 20%, 0.035 g) and the benzyl ether **56** (0.027 g, 0.023 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen, and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 12 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. The crude intermediate (0.017 g, lyophilized) is taken up in 1 M aqueous $NaHCO_3$ solution (0.3 ml) and over the course of 5 hours, several small portions (30 bis 50 µl) of an approx. 1 M solution of 3,4-dimethoxybenzoyl chloride in toluene are added, until a test by thin-layer chromatography (silica gel TLC plates, mobile phase: *n*-butanol/water/acetone/

glacial acetic acid/NH_4OH 70:60:50:18:1.5) indicates complete conversion of the intermediate. The pH of the solution is kept basic during this reaction by adding several portions of solid $NaHCO_3$ (about 0.025 g in total). The reaction mixture is then concentrated in vacuo, and the residue is taken up in a little water and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 65:35), resulting in the target molecule **B1.58** (0.008 g, 39 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 7.41 (br d, J=8.3 Hz, 1H), 7.32 (br s, 1H), 7.04 (d, J=8.3 Hz, 1H), 5.05 (d, J=3.9 Hz, 1H), 4.51 (d, J=7.8 Hz, 1H), 4.14 (q, J=6.7 Hz, 1H), 4.09 (t, J=4.1 Hz, 1H), 3.82 (s, 6H), 3.33 (dd, J=3.1, 9.6 Hz, 1H), 1.13 (d, J=6.3 Hz, 3H), 0.68 (t, J=7.6 Hz, 3H); MS (FAB, THG) 923 (M+Na), 901 (M+H), 879 (M+2H-Na).

Example B39: Preparation of compound **B1.59**.

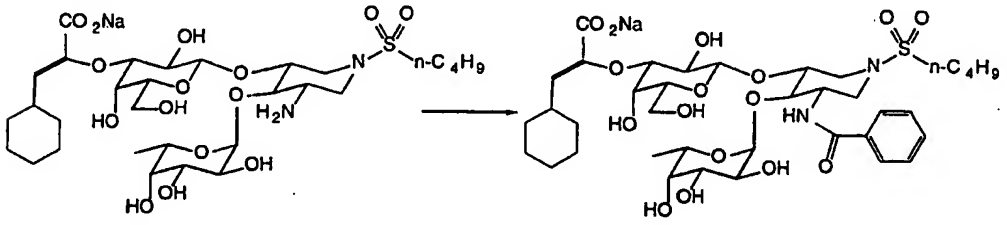


56 **B1.59**

Dioxane (5.3 ml), water (2.6 ml) and acetic acid (1.1 ml) are added to a mixture of $Pd(OH)_2/C$ (Pearlman catalyst, Pd content 20%, 0.13 g) and the benzyl ether **56** (0.12 g, 0.1 mmol). The flask is evacuated and flushed with argon several times. It is then flushed with hydrogen and the black reaction mixture is hydrogenated under a slightly elevated pressure of hydrogen at room temperature for 24 hours and then filtered through a cellulose filter (pore size 45 µm). The filtrate is concentrated in vacuo, and the residue is taken up with water and concentrated again several times in order to remove excess acetic acid. The crude amine (0.074 g) is taken up in a little water and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck

RP18 silica gel, elution: methanol/H_2O 1:1), resulting in the target molecule **B1.59** (0.052 g, 73 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 5.00 (d, J=3.6 Hz, 1H), 4.41 (d, J=7,7 Hz, 1H), 4.28 (q, J=6.5 Hz, 1H), 3.83 (d, J=3.1 Hz, 1H), 3.79 (dd, J=3.1, 9.7 Hz, 1H), 3.32 (dd, J=3.2, 9.6 Hz, 1H), 1.12 (d, J=6.1 Hz, 3H), 0.83 (t, J=7.9 Hz, 3H); MS (FAB, THG) 737 (M+Na), 713 (M+H).

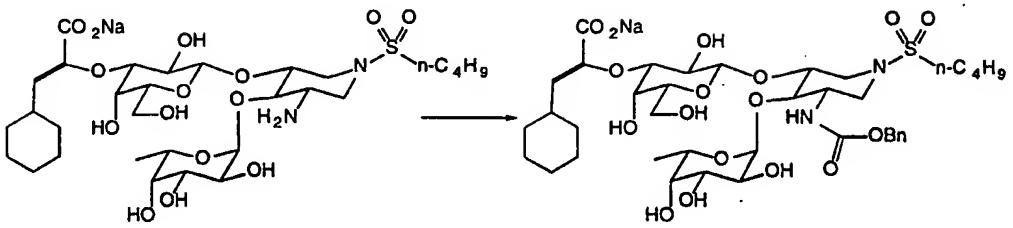
Example B40: Preparation of compound **B1.60**.



B1.59 **B1.60**

The amine **B1.59** (0.027 g, 0.038 mmol) is taken up in 1 M aqueous $NaHCO_3$ solution (0.35 ml) and, over the course of 4 hours, several small portions (30 to 50 µL) of an approx. 0.5 M solution of benzoyl chloride in toluene are added until a test by thin-layer chromatography (silica gel TLC plates, mobile phase: *n*-butanol/water/acetone/glacial acetic acid/ NH_4OH 70:60:50:18:1.5) indicates complete conversion. The pH of the solution is kept basic throughout the reaction by adding several portions of solid $NaHCO_3$ (about 0.01 g in total). The reaction mixture is then concentrated in vacuo, and the residue is taken up in a little water and purified by gel filtration on Bio-Gel P2 (particle size 65 µm, column diameter 2.5 cm, length 35 cm, eluent: water, flow rate 0.45 ml/min, detection at 215 nm) and subsequent reverse phase chromatography (Merck RP18 silica gel, elution: methanol/H_2O 1:1), resulting in the target molecule **B1.60** (0.027 g, 85 %) as a fluffy white solid (after lyophilization): ^1H NMR (400 MHz, D_2O) δ 7.72 (d, J=8.0 Hz, 2H), 7.52 (t, J=6.9 Hz, 1H), 7.44 (t, J=7.5 Hz, 2H), 5.05 (d, J=3.8 Hz, 1H), 4.50 (d, J=8.1 Hz, 1H), 4.17 (q, J=6.6 Hz, 1H), 3.92 (br d, J=10.4 Hz, 1H), 3.85 (d, J=2.8 Hz, 1H), 3.80 (dd, J=3.1, 10.4 Hz, 1H), 3.33 (dd, J=2.8, 9.8 Hz, 1H), 1.12 (d, J=7,1 Hz, 3H), 0.70 (t, J=8.2 Hz, 3H); MS (FAB, THG) 863 (M+Na), 841 (M+H).

Example B41: Preparation of compound **B1.61**.

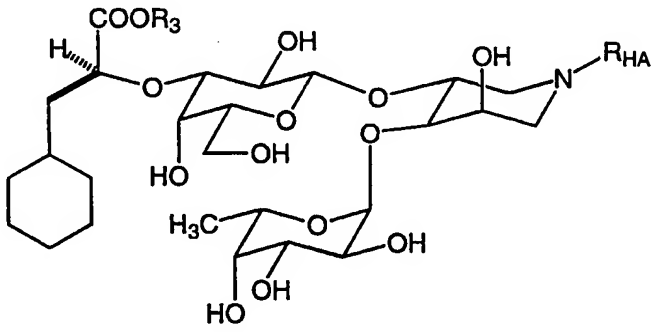


B1.59 **B1.61**

The carbamate **B1.61** is prepared starting from the amine **B1.59** (0.027 g, 0.038 mmol) using benzyl chloroformate as reagent in analogy to Example B40 (Preparation of compound **B1.60**). The yield is 0.007 g (21 %): ^{1}H NMR (400 MHz, D_2O) δ 7.31 (m, 5H), 5.06 (d, J=12.0 Hz, 1H), 4.97 (d, J=12.0 Hz, 1H), 4.96 (d, J=4.0 Hz, 1H), 4.42 (d, J=7.7 Hz, 1H), 4.19 (q, J=6.6 Hz, 1H), 3.96 (br s, 1H), 3.80 (d, J=2.9 Hz, 1H), 3.50 (dd, J=8.2, 9.4 Hz, 1H), 3.29 (dd, J=2.9, 9.7 Hz, 1H), 3.20 (br d, J=12.2 Hz, 1H), 1.06 (d, J=6.5 Hz, 3H), 0.77 (t, J=8.0 Hz, 3H); MS (FAB, THG) 871 (M+H), 849 (M+2H-Na).

The following compounds are prepared in analogy to the above examples:

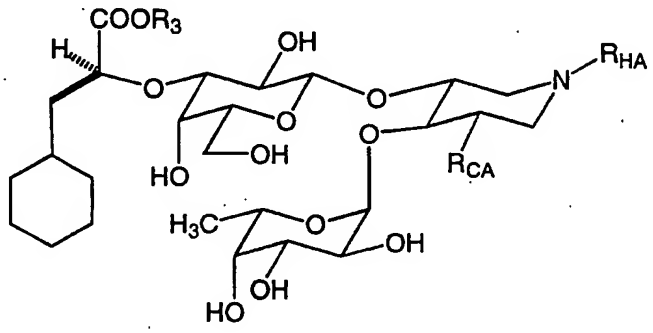
Table 1a:



Compound No.	R_3	R_{HA}
B1.64	Na	C(O)-3,4-$(OH)_2$-C_6H_5
B1.65	Na	C(O)CH$(C_6H_5)_2$
B1.68	Na	C(O)-3,4-$(OCH_2C_6H_5)_2$-C_6H_5

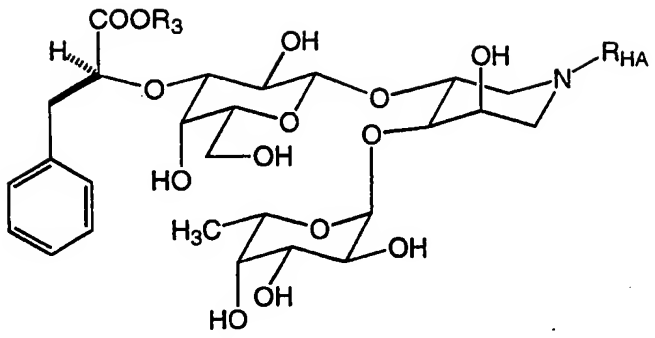
Compound No.	R_3	R_{HA}
B1.70	Na	C(O)-3,4,5-$(OH)_3$-C_6H_6
B1.72	Na	C(O)[CH(OH)]$_2$C(O)ONa
B1.73	Na	$C(O)CH_3$
B1.77	Na	$S(O)_2(CH_2)_2C_{10}H_7$
B1.78	H	H
B1.80	Na	$S(O)_2CH_2C_6H_5$
B1.81	Na	$C(O)NHC_6H_5$
B1.82	Na	$C(O)C_6H_{11}$
B1.83	Na	$S(O)_2(CH_2)_3CH_3$
B1.84	Na	$C(O)O(CH_2)_2CH_3$

Table 1a':



Compound No.	R_3	R_{HA}	R_{CA}
B1.62	Na	$C(O)CH_3$	$NHC(O)C_{10}H_7$
B1.63	Na	$C(O)CH_3$	$NHC(O)OCH_2C_6H_5$
B1.66	Na	$C(O)CH_3$	$NHC(O)CH_2C_6H_5$
B1.67	Na	$C(O)CH_3$	$NHC(O)CH_2OC_6H_5$
B1.69	Na	$C(O)CH_3$	$NHC(O)CH_2NHC(O)OCH_2C_6H_5$
B1.71	Na	$C(O)O(CH_2)_2CH_3$	$NHS(O)_2CH_2C_6H_5$
B1.74	Na	$S(O)_2(CH_2)_3CH_3$	$NHC(O)OCH_2C_6H_5$
B1.75	Na	$S(O)_2(CH_2)_3CH_3$	$NHC(O)C_6H_5$
B1.76	H	$S(O)_2(CH_2)_3CH_3$	NH_2
B1.79	Na	$S(O)_2(CH_2)_3CH_3$	NHC(O)-3,4-$(OCH_3)_2C_6H_3$

Table 1b:

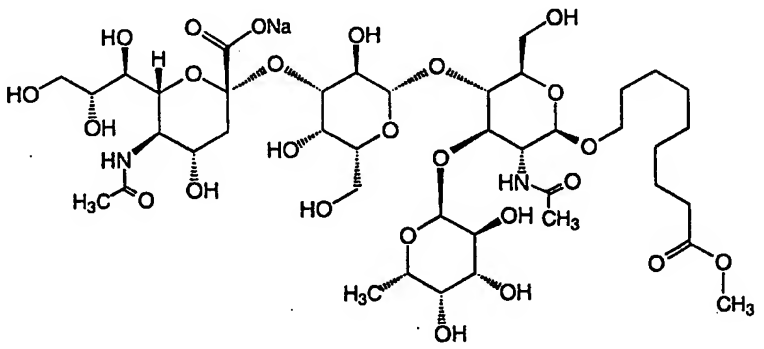


Compound No.	R_3	R_{HA}
B1.85	Na	$S(O)_2$-4-CH_3-C_6H_4
B1.86	Na	$C(O)(CH_2)_8C(O)OCH_3$
B1.87	Na	$S(O)_2(CH_2)_3CH_3$
B1.88	H	$(CH_2)_2CH_3$
B1.89	Na	$C(O)C_6H_5$
B1.90	Na	$C(O)CH_3$
B1.91	Na	$C(O)O(CH_2)_2CH_3$

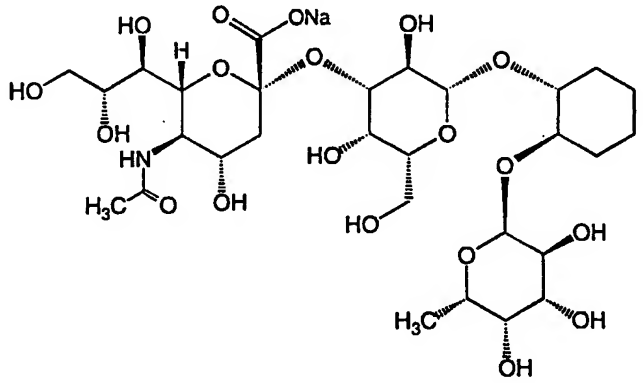
C. Ligand Binding Assay for Determination of IC_{50} Values-conserved use of positive controls E-selectin/human IgG chimera [cloned and expressed according to Kolbinger et al. Biochemistry 35:6385-6392 (1996)] are incubated in Falcon probind™ microtiter plate (Plate 1) at a concentration of 200 ng/well in 0.01 M Tris, 0.15 M NaCl, 1 mM $CaCl_2$, pH 7.4 (Tris-Ca^{++} buffer). Thus the plating solution is dispensed as 100 µl/well of 2 µg/ml E-chimera. Row 12 is left blank with only buffer. Plate 1 is incubated covered at 37°C for 2 hours. After incubation 100 µl/well of 2 % BSA in Tris Ca^{++} buffer is added and incubated at room temperature for 1 hour. During incubation the compounds (2x serial dilution) are titrated in 1 % BSA in Tris-Ca^{++} using U-shaped low bind microtiter plates (Plate 2). The rows are serially diluted up to row 9. Rows 10, 11, and 12 are just buffer. Final volume is 60 µl/well and the first well contains 10 mM of compound with the exception of the positive controls, A (SLe^x-Lemieux) and B are used as positive controls for each plate and the first well contains 5 mM of these compounds. PolySLe^{a}SA-HRP conjugate is prepared in advance by incubating Sialyl Le^a-PAA-biotin (cat #01-044, GlycoTech Corp., Rockville, MD) with Streptavidin-HRP in a molar ratio of 1:2. 60 µl/well of 1 ng/µl of polySLe^{a}SA-HRP conjugate in 1 % BSA in Tris-Ca^{++} are added to all wells except row 11 in Plate 2. Plate 1 is

washed four times with Tris-Ca^{++} in the automatic plate washer. 100 µl/well are transferred from Plate 2 to Plate 1 starting from lowest concentration of compound. Plate 2 is discarded. The plate is incubated while rocking at room temperature for 2 hours. The plate is washed 4 times with Tris-Ca^{++} using automatic plate washer. 100 µl/well of Substrate [Mix 3,3',5,5'-tetramethylbenzidine reagent and H_2O_2, at 1:1 ratio] are added with an 8 channel pipettor from right to left. The plate is incubated at room temperature for 2 minutes. The reaction is stopped by adding 100µl/well of 1M H_3PO_4 using the 8 channel pipettor from right to left. Absorbance of light at 450nm is measured in a microtiter plate reader.

Control compound A:



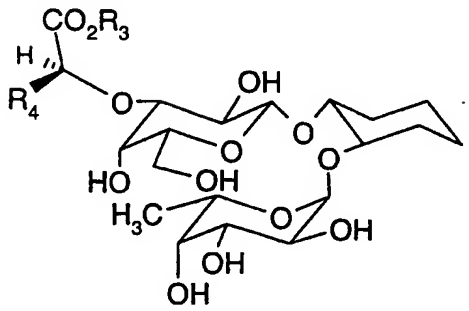
Control compound B:



IC_{50} is calculated by determining the concentration of compound required to inhibit maximal binding of the polySialylLe^{a}HRP conjugate to immobilized E-selectin/human IgG chimera by 50%. The relative IC_{50} is calculated by determining the ratio of the IC_{50} of an internal control compound to the IC_{50} of the test compound.

In the following tables RIC_{50} means $\frac{IC_{50}(\text{Test compound})}{IC_{50}(\text{Control compound A})}$

Table 2:



Comp. No.	R_3	R_4	RIC_{50}
B1.1	Na	$-CH_2C_6H_5$	0.35
B1.2	Na	$CH_2C_6H_{11}$	0.08
B1.3	Na	$-CH_2NHC(O)C_6H_5$	1.11
B1.4	Na	$-CH_2NHC(O)(CH_2)_2C_6H_5$	1.85
B1.5	Na	$-CH_2NHC(O)(CH_2)_3OH$	1.23
B1.6	H	$-CH_2NH_2$	0.96
B1.7	H	$-CH_2NHCH_2(CH)_2C_6H_5$	1.15
B1.8	Na	$-CH_2N[C(O)C_6H_5]CH_2(CH)_2C_6H_5$	0.90
B1.9	H	$CH_2NHCH_2C_6H_5$	0.61
B1.10	Na	$-CH_2N(CH_2C_6H_5)_2$	0.60
B1.11	H	$-CH_2NH[CH_2CH(CH_3)_2$	0.74
B1.12	H	$-CH_2N[CH_2CH(CH_3)_2]_2$	0.32
B1.13	Na	$-CH_2N[C(O)C_6H_5][CH_2CH(CH_3)_2]$	0.21
B1.14	Na	$-CH_2NH[SO_2(C_6H_4)NO_2]$	0.12
B1.15	Na	$-CH_2NHSO_2C_6H_4CH_3$	0.13
B1.16	Na	$-CH_2NHC(O)CF_3$	0.64
B1.17	Na	$-CH_2NHC(O)C_6H_{11}$	1.33
B1.18	Na	$-CH_2CH_2C_6H_5$	0.14
B1.19	Na	$-CH_2CH_2C_6H_{11}$	0.17

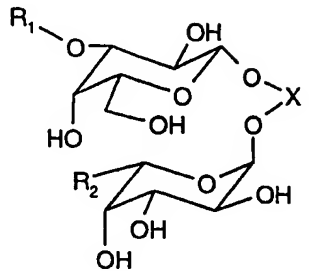
Comp. No.	R_3	R_4	RIC_{50}
B1.20	Na	$-CH_2NHC(O)C_{11}H_{23}$	1.76
B1.21	Na	$-CH_2NHC(O)CH(C_6H_5)_2$	0.71
B1.22	Na	$-CH_2NHC(O)C_2H_4CO_2Na$	1.05
B1.23	Na	$-CH_2NHC(O)C_6[(1,3,4,5)OH]_4H_7$	0.79
B1.24	Na	$-CH_2NHC(O)C_6H_4SO_3Na$	0.93
B1.25	Na	$-CH_2NHC(O)C_6H_4Cl$	1.29
B1.26	Na	$-CH_2NHC(O)C_6H_4NO_2$	1.21
B1.27	Na	$-CH_2NHC(O)C_6H_4OCH_3$	1.15
B1.28	Na	$-CH_2NHC(O)C_6H_4(3,4)Cl_2$	2.04
B1.29	Na	$-CH_2NHC(O)C_6H_4CH_3$	1.30
B1.30	Na	$-CH_2NHC(O)C_6H_4C_6H_5$	1.65
B1.31	Na	$-CH_2NHC(O)C_6H_4CN$	1.04
B1.32	Na	$-CH_2NHC(O)C_{10}H_7$	1.44
B1.9	Na	$-CH_2NHCH_2C_6H_5$	0.61
B1.33	Na	$-CH_2NHC(O)C_6H_4COONa$	0.96
B1.34	Na	$-CH_2NHC(O)(CHOH)_2COONa$	0.78
B1.35	Na	$-CH_2N[C(O)C_6H_5]CH_2C_6H_5$	0.44
B1.36	Na	$-CH_2N[C(O)C_6H_5](CH_2)_3C_6H_5$	0.57
B1.37	Na	$-CH_2NHSO_2CF_3$	0.26
B1.38	Na	$-CH_2N[CH_2CH(CH_3)]SO_2C_6H_4NO_2$	0.32

Table 2a:

Compound No.	RIC_{50}	Compound No.	RIC_{50}
B1.62	0.949	B1.77	0.618
B1.64	0.287	B1.78	0.304
B1.65	0.862	B1.79	0.196
B1.66	1.112	B1.80	0.203
B1.67	0.564	B1.81	0.216
B1.68	0.696	B1.82	0.195
B1.69	2.661	B1.83	0.176
B1.70	0.199	B1.84	0.169
B1.71	0.414	B1.85	1.28
B1.72	0.186	B1.86	2.733
B1.73	0.249	B1.87	0.520
B1.74	0.134	B1.88	1.257
B1.75	0.102	B1.89	0.696
B1.76	0.451	B1.90	0.569
B1.63	0.087		

WHAT IS CLAIMED IS:

1. A compound of the formula I



(I)

in which

X is the residue of a non-glycosidic aliphatic 1,2-diol;

R_1 is an S-configurated methyl substituted with one carboxyl residue and one other substituent; and

R_2 is hydrogen, C_1-C_{12}alkyl or C_6aryl; where the alkyl and the aryl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal; including its physiologically tolerated salts.

2. A compound according to claim 1, wherein

(a) NH_2, primary amino, secondary amino, carbamide, carbamate, carbhydrazide, sulfonamide, sulfonhydrazide and aminocarbonylamide is a representative selected from the group of $R_8C(O)(NH)_pN(R_9)$-, $-C(O)(NH)_pNR_8R_9$, $R_8OC(O)(NH)_pN(R_9)$-, $R_8R_{40}NC(O)(NH)_pN(R_9)$-, $-OC(O)(NH)_pNR_8R_9$, $-N(R_{40})C(O)(NH)_pNR_8R_9$, $R_8S(O)_2(NH)_pN(R_9)$-; $-S(O)_2(NH)_pNR_8R_9$; $R_8R_{40}NS(O)_2N(R_9)$- or $-NR_{40}S(O)_2NR_8R_9$, in which R_8, R_9 and R_{40} are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_1-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, C_6-C_{15}heteroaralkyl, C_6-C_{15}heteroaralkenyl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, or $R_{8'}R_{9'}N$ in which $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, OH, SO_3M_y, OSO_3M_y, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, which are unsubstituted or substituted by one or more substituents; or R_8 and R_9 or $R_{8'}$ and $R_{9'}$ or R_8 and R_{40} in the case of $-NR_8R_9$ or $-NR_{8'}R_{9'}$ or $R_8R_{40}N$- together are tetramethylene, pentamethylene, $-(CH_2)_2$-O-$(CH_2)_2$-, $-(CH_2)_2$-S-$(CH_2)_2$- or $-(CH_2)_2$-NR_7-$(CH_2)_2$-, and R_7 is H, C_1-C_6alkyl, C_7-C_{11}aralkyl, $C(O)R_{s2}$ or sulfonyl; and

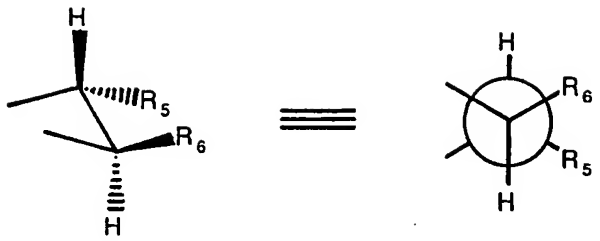
(b) sulfonyl is a representative of the formula R_{10}-SO_2- in which R_{10} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, which are unsubstituted or substituted by one or more substituents; wherein the substituents are selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocyclo-

alkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are substituted or substituted by one of the abovementioned substituents; p is 0 or 1 and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

3. A compound according to claim 1, wherein X is a linear or branched C_2-C_{20}-alkylene, -alkenylene, C_3-C_{12}-cycloalkylene, -cycloalkenylene, C_3-C_{11}-heterocycloalkylene or -heterocycloalkenylene with hetero atoms selected from the group of -O-, -S- and -N-.

4. A compound according to claim 1, wherein X is substituted by a substituent selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and amidocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

5. A compound as claimed in claim 1, wherein X is the residue of a 1,2-diol corresponding to formula II



(II)

in which

R_5 and R_6 are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; or R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_3-C_{12}-cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group -O-, -S- and -N-;

where alkyl, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkylene, cycloalkenylene, heterocycloalkylene and heterocycloalkenylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

6. A compound according to claim 5, wherein R_5 and R_6

(a) are unsubstituted or substituted by C_1-C_{12}alkyl or C_1-C_{12}alkoxy;

(b) are, together with the group -CH-CH-, a 5- to 8-membered carbocycle;

(c) are, together with the group -CH-CH-, a 5- to 8-membered heterocarbocycle;

(d) are, independently of one another, hydrogen, unsubstituted C_1-C_{12}alkyl or C_1-C_{12}alkyl which is substituted by a substituent selected from the group consisting of -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_3-C_{12}cycloalkyl, C_1-C_6alkoxy, phenyloxy and benzyloxy; unsubstituted C_3-C_{12}cycloalkyl or C_3-C_{12}cycloalkyl which is substituted by a substituent selected from the group consisting of -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_1-C_6alkyl, C_1-C_6alkoxy, phenyloxy and benzyloxy; C_6-C_{10}aryl which is unsubstituted or substituted by -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_1-C_6alkyl or C_1-C_6alkoxy; C_3-C_9heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms; or C_7-C_{12}aralkyl which is unsubstituted or substituted by -C(O)OR_{s1}, -OC(O)R_{s4}, -C(O)ONa or -C(O)OK, primary amino, secondary amino, C_1-C_6alkyl or C_1-C_6alkoxy;

(e) are, together with the group -CH-CH-, a 5- to 12-membered carbocycle or 5- or 6-membered heterocarbocycle with a hetero atom selected from the group consisting of oxygen and nitrogen atoms; or

(f) are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_4-C_{12}cycloalkenylene, C_2-C_{11}heterocycloalkylene or C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group of -O-, -S- and -N-;

where cycloalkylene, cycloalkenylene, heterocycloalkylene and heterocycloalkenylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)OR_{s1}, OC(O)R_{s4}, C(O)R_{s2}, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen,

C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

7. A compound according to claim 6, wherein R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene or C_2-C_{11}heterocycloalkylene with nitrogen as hetero atom; where cycloalkylene and heterocycloalkylene are unsubstituted or substituted by one or more substituents according to claim 6.

8. A compound according to claim 7, wherein R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene or C_2-C_{11}heterocycloalkylene with nitrogen as hetero atom; where cycloalkylene and heterocycloalkylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, NR_8R_9, C_1-C_{12}alkyl, $R_8C(O)(NH)_pN(R_9)$-, $-C(O)(NH)_pNR_8R_9$, $R_8S(O)_2(NH)_pN(R_9)$-; $R_8R_{40}NC(O)(NH)_pN(R_9)$-, $R_8OC(O)(NH)_pN(R_9)$-, $-OC(O)(NH)_pNR_8R_9$, and R_{10}-SO_2-, in which R_8, R_9, R_{10} and R_{40} are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_1-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}hetero-cycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_8-C_{16}aralkenyl with C_2-C_6alken-ylene and C_6-C_{10}aryl, C_6-C_{15}heteroaralkyl, C_6-C_{15}heteroaralkenyl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryl-oxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide; R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cyclo-alkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or

C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, heteroaralkyl, aralkenyl and heteroaralkenyl as substituents in turn are unsubstituted or substituted by one of the above-mentioned substituents; p is 0 or 1 and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

9. A compound according to claim 8, wherein R_8 and R_9 are, independently of one another hydrogen; C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl, C_6-C_{10}aryl, C_7-C_{16}aralkyl with 1 to 6 C atoms in the alkylene group and C_6-C_{10}aryl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, where R_8 and R_9 are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, COOH, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, C_6-C_{10}aryloxy, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, NO_2, amino, primary amino, secondary amino and CN, and R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

10. A compound according to claim 8, wherein R_{10} is C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl, C_6-C_{10}aryl, C_7-C_{16}aralkyl with 1 to 6 C atoms in the alkylene group and C_6-C_{10}aryl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6alkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, COOH, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, NO_2, amino, primary amino, secondary amino and CN; where R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

11. A compound according to claim 10, wherein R_{10} is C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl, C_6-C_{10}aryl, C_7-C_{16}aralkyl with 1 to 6 C atoms in the alkylene group and C_6-C_{10}aryl, which are

unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, $C(O)OM_y$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, nitro, amino, primary amino, secondary amino and cyano; or C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6alkyl.

12. A compound according to claim 8, wherein R_5 and R_6 are, together with the -CH-CH-group, C_3-C_{12}cycloalkylene or C_2-C_{11}heterocycloalkylene with nitrogen as hetero atom; where cycloalkylene and heterocycloalkylene are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, NH_2, C_1-C_{12}alkyl, $R_8C(O)N(R_9)$-, $-C(O)NR_8R_9$, $R_8S(O)_2N(R_9)$-; $R_8OC(O)N(R_9)$- and R_{10}-SO_2-, in which R_9 is hydrogen and R_8 is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, which are unsubstituted or substituted by one or more C_1-C_{12}alkoxy; R_{10} is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more C_1-C_{12}alkyl; R_{s1} and R_{s4} are C_1-C_{12}alkyl and R_{s2} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkenyl, C_3-C_{12}cycloalkyl or C_6-C_{10}aryl, and alkyl, cycloalkenyl, cycloalkyl and aryl as substituents in turn are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1'}$ and $OC(O)R_{s4'}$ where $R_{s1'}$ is M_y or C_1-C_{12}alkyl and $R_{s4'}$ is C_1-C_{12}alkyl; y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

13. A compound according to claim 12, wherein R_5 and R_6 are, together with the -CH-CH-group, cyclohexylene.

14. A compound according to claim 8, wherein R_5 and R_6 are, together with the -CH-CH-group, piperidylene.

15. A compound according to claim 14, wherein R_5 and R_6 are, together with the -CH-CH-group, piperidylene; where the hetero atom is unsubstituted or substituted by a substituent selected from the group consisting of $C(O)OR_{s1}$, $C(O)R_{s2}$, $C(O)NR_8R_9$, NH_2, SO_3M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, sulfonhydrazide, and one or more C atoms of the ring are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $OC(O)R_{s4}$, NH_2, OSO_3M_y

$NR_{20}SO_3M_y$, C_1-C_{12}alkoxy, C_6-C_{10}aryloxy, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyloxy, primary amino, secondary amino, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_8 and R_9 are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{16}aralkyl, C_6-C_{15}heteroaralkyl, C_8-C_{16}aralkenyl with C_2-C_6alkenylene and C_6-C_{10}aryl, or di-C_6-C_{10}aryl-C_1-C_6-alkyl, or R_8 and R_9 together are tetramethylene, pentamethylene, $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_2-S-(CH_2)_2-$ or $-(CH_2)_2-NR_7-(CH_2)_2-$, and R_7 is H, C_1-C_6alkyl, C_7-C_{11}aralkyl, $C(O)R_{s2}$ or sulfonyl; and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

16. A compound according to claim 15, wherein R_5 and R_6 are, together with the -CH-CH- group, piperidylene; where the hetero atom is unsubstituted or substituted by a substituent selected from the group consisting of $C(O)OR_{s1}$, $C(O)R_{s2}$, $-C(O)NR_8R_9$ and R_{10}-SO_2- and one or more C atoms of the ring are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, NH_2, $R_8S(O)_2N(R_9)$-; $R_8C(O)N(R_9)$- and $R_8OC(O)N(R_9)$-, where R_9 is hydrogen and R_8 is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, where alkyl, aryl and aralkyl are unsubstituted or substituted by one or more C_1-C_{12}alkoxy; R_{10} is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more C_1-C_{12}alkyl; R_{s1} is C_1-C_{12}alkyl and R_{s2} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkenyl, C_3-C_{12}cycloalkyl or C_6-C_{10}aryl, and alkyl, cycloalkenyl, cycloalkyl and aryl as substituents in turn are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1'}$ and $OC(O)R_{s4'}$ where $R_{s1'}$ is M_y or C_1-C_{12}alkyl and $R_{s4'}$ is C_1-C_{12}alkyl; y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

17. A compound according to claim 8, wherein R_5 and R_6 are, together with the -CH-CH- group, piperidylene; which is unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, NH_2, C_1-C_{12}alkyl, $R_8C(O)N(R_9)$-, -C(O) NR_8R_9, $R_8S(O)_2N(R_9)$-; $R_8OC(O)N(R_9)$-, $R_8R_{40}NC(O)N(R_9)$-, $-OC(O)NR_8R_9$ and R_{10}-SO_2-, in which R_9 is hydrogen and R_8 is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, where alkyl, aryl and aralkyl are unsubstituted or substituted by one or more C_1-C_{12}alkoxy or C_7-C_{11}aralkyloxy; R_{10} is C_1-C_{12}alkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more C_1-C_{12}alkyl; R_{40} is hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; R_{s1} and R_{s4} are C_1-C_{12}alkyl and R_{s2} is C_1-C_{12}alkyl, C_3-C_{12}cycloalkenyl, C_3-C_{12}cycloalkyl or C_6-C_{10}aryl, and alkyl, cycloalkenyl, cycloalkyl and aryl as substituents in turn are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, $C(O)OR_{s1'}$ and $OC(O)R_{s4'}$ where $R_{s1'}$ is M_y or C_1-C_{12}alkyl and $R_{s4'}$ is C_1-C_{12}alkyl; y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

18. A compound according to claim 1, wherein X is cyclohexylene or piperidylene which is unsubstituted or substituted by one or more substituents selected from the group consisting of OH, NH_2, C_3H_7, $-C(O)CH_3$, $-C(O)C_6H_5$, $-C(O)(CH_2)_8C(O)OCH_3$, $-C(O)[CH(OH)]_2C(O)ONa$, $C(O)$-$C_6H_8(OH)_3$, $-C(O)$-C_6H_{11}, $-C(O)OC_3H_7$, $-C(O)NHC_6H_5$, $-NHS(O)_2CH_2C_6H_5$, $-NHC(O)OCH_2C_6H_5$, $-NHC(O)C_6H_3(OCH_3)_2$, $-S(O)_2$-C_4H_9, $-NHC(O)NHC_6H_5$, $-S(O)_2$-$C_6H_4CH_3$, $-S(O)_2$-$CH_2C_6H_5$ and $-S(O)_2$-$(CH)_2C_{10}H_7$.

19. A compound according to claim 1, wherein R_2 is C_1-C_6alkyl.

20. A compound according to claim 1, wherein substituents for R_2 are selected from halogen, $-C(O)OM_y$, C_1-C_6alkyl, C_1-C_4alkoxy, phenyl, naphthyl, $-SO_3M_y$, C_1-C_{12}primary amino, C_2-C_{20}secondary amino, $-SO_2$-NR_8R_9 and -C(O)-NR_8R_9 in which R_8 and R_9 are, independently of one another, H, C_1-C_4alkyl, C_2-C_4hydroxyalkyl, phenyl or benzyl, or R_8 and R_9 together with the N atom are morpholino, thiomorpholino, pyrrolidino or piperidino.

21. A compound according to claim 1, wherein R_2 is hydrogen, unsubstituted C_1-C_6alkyl or C_1-C_6alkyl, which is substituted by C(O)OH, -C(O)ONa, -C(O)OK, -OH, -C(O)-NR_8R_9 or $-SO_2$-NR_8R_9, in which R_8 is H, C_1-C_4alkyl, C_2-C_4hydroxyalkyl, phenyl or benzyl, and R_9 in-

dependently has the meaning of R_8, or R_8 and R_9 are together tetramethylene, pentamethylene or $-CH_2CH_2-O-CH_2CH_2-$.

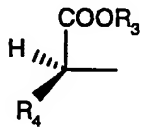
22. A compound according to claim 21, wherein R_2 is hydrogen, methyl, ethyl, $HO(O)C-CH_2CH_2-$, $NaOC(O)-CH_2CH_2-$ or $R_8R_9N-C(O)-CH_2CH_2-$, and R_8 and R_9 are, independently of one another, H, C_1-C_6alkyl, C_2-C_4hydroxyalkyl, phenyl, benzyl or, together, morpholino.

23. A compound according to claim 1, wherein the other substituent in R_1 has 1 to 20 C atoms.

24. A compound according to claim 23, wherein the other substituent is selected from the group consisting of unsubstituted and substituted C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl and C_7-C_{10}heteroaralkenyl.

25. A compound according to claim 24, wherein the other substituent is substituted methyl, or 2-substituted ethyl or cyclohexyl.

26. A compound as claimed in claim 1, wherein R_1 corresponds to a group of the formula III,



(III),

in which

R_3 is hydrogen or M_y; and

R_4 is C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl or C_7-C_{10}heteroaralkenyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-

C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

27. A compound according to claim 26, wherein R_3 is hydrogen or M_y and R_4 is
(a) unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of -NH_2, primary amino, secondary amino, C_1-C_{12}sulfonyl, carbamide, carbamate, carbhydrazide, sulfonamide, sulfonhydrazide, aminocarbonylamido, C_3-C_{12}cycloalkyl, C_1-C_6alkoxy, phenyloxy and benzyloxy; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more substituents selected from the group consisting of C_3-C_{12}cycloalkyl, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_{12}sulfonyl, phenyloxy and benzyloxy; C_6-C_{10}aryl; C_3-C_9heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms; C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; C_4-C_{16}heteroaralkyl with C_1-C_6alkyl and C_3-C_{10}heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms and a total of 3 to 5 carbon atoms; C_6-C_{10}aryl, C_3-C_9heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms, C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, C_3-C_{16}heteroaralkyl with C_1-C_6alkyl and C_4-C_{10}heteroaryl with 1 or 2 hetero atoms selected from the group consisting of oxygen and nitrogen atoms and a total of 3 to 5 carbon atoms, which are substituted by one or more substituents selected from the group consisting of OH, halogen, C_1-C_{12}sulfonyl, carboxyl, C(O)OM_y, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl,

SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, nitro, NH_2, primary amino, secondary amino, carbamide, carbamate, sulfonamide and cyano, in which y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal, or

(b) C_1-C_{12}alkyl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide,

where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

28. A compound according to claim 27, wherein R_3 is hydrogen, K or Na.

29. A compound according to claim 27, wherein R_4 is methyl, ethyl, n- or i-propyl, n-, i- or t-butyl, cyclohexyl, naphthyl, phenyl, benzyl, naphthylmethyl, 2-phenylethyl, 3-phenylpropyl, cyclohexylmethyl, 2-cyclohexylethyl, furanyl, pyridinyl or pyrimidinyl.

30. A compound according to claim 27, wherein carbamido, carbhydrazido, sulfonamido, sulfonhydrazido, aminocarbonylamide and carbamate as substituent for R_4 mean groups of the formulae $R_8NHC(O)N(R_9)$-, $R_8OC(O)N(R_9)$-, $R_8C(O)(NH)_pN(R_9)$- and $R_8S(O)_2(NH)_pN(R_9)$-, in which R_8 is H, C_1-C_{12}alkyl, C_5- or C_6cycloalkyl, C_5- or C_6cycloalkylmethyl or -ethyl-, C_5- or C_6heterocycloalkyl, C_5- or C_6heterocycloalkylmethyl or -ethyl-, phenyl, naphthyl, benzyl,

2-phenylethyl, diphenylmethyl, which are unsubstituted or substituted by one or more substituents from the group of -OH, $-NH_2$, C_1-C_8primary amino, C_2-C_{14}secondary amino, NO_2, -CN, -F, -Cl, -C(O)OH, -C(O)ONa, $-SO_3H$, $-OSO_3Na$, $NR_{20}SO_3Na$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and $-SO_3Na$, C_1-C_4alkyl, C_1-C_4alkoxy and phenyl, and R_9 is H, C_1-C_{10}alkyl, phenyl, naphthyl, benzyl, 2-phenylethyl or phenyl-CH=CH-CH_2-, and p is 0 or 1.

31. A compound according to claim 27, wherein R_4 is a

(a) carbamido-substituted alkyl group R_8-C(O)NR_9-$(CH_2)_n$-, where n is 1 or 2, R_8 is hydrogen; C_1-C_{12}alkyl; C_3-C_{12}cycloalkyl; C_6-C_{10}aryl or C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; wherein alkyl, cycloalkyl, aryl and aralkyl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, -C(O)OM_y, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C(O)OR_{s1}, OC(O)R_{s4}, nitro, amino and cyano; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl or di-C_6-C_{10}aryl-C_1-C_6alkyl; and R_9 is H, linear or branched C_1-C_{10}alkyl, C_5- or C_6cycloalkyl, C_5- or C_6cycloalkylmethyl- or -ethyl, phenyl, naphthyl or benzyl, 2-phenylethyl or phenyl-CH=CH-CH_2-; y is 1 and M is an alkali metal or y is 1/2 and M is an alkaline earth metal, R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl;

(b) a sulfonamide-substituted alkyl group R_8-SO_2NR_9-$(CH_2)_n$- in which R_8, R_9 and n have the meanings indicated in (a);

(c) an aminocarbonylamide- or carbamate-substituted alkyl group R_9NH-C(O)-NH-$(CH_2)_n$ or R_9O-C(O)-NH-$(CH_2)_n$ in which R_9 has the meanings indicated in (a) and additionally phenyl and n has the meanings indicated in (a);

(d) a carbhydrazido-substituted alkyl group R_8-C(O)-NHNR_9-$(CH_2)_n$- in which R_8, R_9 and n have the meanings indicated in (a); or

(e) a sulfonhydrazido-substituted alkyl group R_8-SO_2-NHNR_9-$(CH_2)_n$- in which R_8, R_9 and n have the meanings indicated in (a).

32. A compound according to claim 27, wherein R_4 is an

(a) amide $R_8C(O)N(R_9)(CH_2)_n$- or $R_8S(O)_2N(R_9)(CH_2)_n$-; where R_8 and R_9 are, independently of one another, hydrogen; unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, C(O)ONa, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, -SO_3H, OSO_3Na, $NR_{20}SO_3Na$, SO_3Na, nitro and cyano; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl substituted by one or more OH; unsubstituted C_6-C_{10}aryl, unsubstituted C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; C_6-C_{10}aryl, or C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, which is substituted by one or more substituents selected from the group consisting of OH, halogen, carboxyl, C(O)ONa, -C(O)OK, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$, $C(O)OR_{s1}$, $OC(O)R_{s4}$, nitro, amino and cyano, R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; and n is 2 or 1; or

(b) sulfonamide $R_8S(O)_2N(R_9)(CH_2)_n$-, where R_8 is C_1-C_{12}alkyl, which is unsubstituted or substituted by one or more halogen atoms; or C_6-C_{10}aryl, which is substituted by one or more C_1-C_4alkyl, C_1-C_4alkoxy, halogen, -CN or -NO_2, and R_9 is hydrogen or isobutyl, and n is 2 or 1; or

(c) aminocarbonylamide R_8-NH-C(O)-$NH(CH_2)_n$-, in which R_8 is C_1-C_{12}alkyl or C_6-C_{10}aryl, which is unsubstituted or substituted by halogen, -CN, -NO_2, C_1-C_4alkyl, C_1-C_4alkoxy, C_5- or C_6cycloalkyl, C_6-C_{10}aryl or C_7-C_{12}aralkyl, and n is 2 or 1; or

(d) aminoalkyl $R_{8'}R_{9'}N(CH_2)_n$-, where $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen; unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, C(O)-$NR_{11}R_{12}$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, -SO_3H, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$, nitro, amino and cyano; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more OH; C_6-C_{10}aryl; C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, where aryl and the aryl in the aralkyl and aralkenyl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, -C(O)ONa, -C(O)OK, -C(O)-$NR_{11}R_{12}$, C_1-C_{12}alkyl, C_1-C_6alkoxy, C_6-C_{10}aryl, -SO_3H, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$, nitro, amino and cyano;

wherein n is 2 and preferably 1, and R_{s1} is hydrogen, K or Na, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{11} is H, C_1-C_4alkyl, C_2-C_4hydroxyalkyl, phenyl or benzyl, and R_{12} independently has the meaning of R_{11}, or R_{11} and R_{12} together are tetramethylene, pentamethylene or $-CH_2CH_2-O-CH_2CH_2-$ and R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl.

33. A compound according to claim 32, wherein R_4 is an amide $R_8C(O)N(R_9)(CH_2)_n$- or $R_8S(O)_2N(R_9)(CH_2)_n$-, where R_8 is unsubstituted C_1-C_{12}alkyl; C_1-C_8alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)ONa and C_6-C_{10}aryl; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_8cycloalkyl which is substituted by one or more OH; unsubstituted C_6-C_{10}aryl or C_7-C_{12}aralkyl with C_1-C_6alkyl; C_6-C_{10}aryl, C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl or C_8-C_{16}aralkenyl with C_2-C_6-alkenyl and C_6-C_{10}aryl, which is substituted by one or more substituents selected from the group consisting of halogen, -C(O)OH, C(O)ONa, C_1-C_{12}alkyl, C_1-C_6alkoxy, $-SO_3H$, SO_3Na, OSO_3Na, $NR_{20}SO_3Na$ in which R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and nitro and cyano; and R_9 is hydrogen; unsubstituted C_1-C_6alkyl, unsubstituted C_6-C_{10}aryl, unsubstituted C_7-C_{12}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, and n is 2 or 1.

34. A compound according to claim 32, wherein R_4 is an amide $R_8C(O)N(R_9)(CH_2)_n$-, where R_8 is unsubstituted C_1-C_{12}alkyl; C_1-C_{12}alkyl which is substituted by one or more substituents selected from the group consisting of cyclohexyl, OH, halogen, -C(O)OH, -C(O)ONa and phenyl; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more OH; unsubstituted C_6-C_{10}aryl; C_6-C_{10}aryl, which is substituted by one or more substituents selected from the group consisting of halogen, C(O)ONa, -C(O)OH, C_1-C_6alkyl, C_1-C_6alkoxy, phenyl, $-SO_3H$, SO_3Na, OSO_3Na, $NHSO_3Na$, nitro and cyano; or C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, and R_9 is hydrogen; unsubstituted C_1-C_6alkyl, unsubstituted C_7-

C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl; or C_8-C_{16}aralkenyl with C_2-C_6alkenyl and C_6-C_{10}aryl, and n is 2 or 1.

35. A compound according to claim 34, wherein R_8 is unsubstituted C_1-C_{12}alkyl; C_1-C_4alkyl which is substituted by one or more substituents selected from the group consisting of OH, halogen, C(O)OH, C(O)ONa and phenyl; unsubstituted C_3-C_{12}cycloalkyl; C_3-C_{12}cycloalkyl which is substituted by one or more OH, unsubstituted C_6-C_{10}aryl; C_6-C_{10}aryl which is substituted by one or more substituents selected from the group consisting of halogen, -C(O)OH, C(O)ONa, C_1-C_6alkyl, C_1-C_6alkoxy, -SO_3H, SO_3Na, OSO_3Na, $NHSO_3Na$, nitro and cyano; or unsubstituted C_7-C_{16}aralkyl with C_1-C_6alkyl and C_6-C_{10}aryl, and R_9 is H, C_1-C_4alkyl, phenyl-CH_2-, phenyl-CH_2CH_2, phenyl-$(CH_2)_3$- or phenyl-CH=CH-CH_2-, and n is 2 or 1.

36. A compound according to claim 32, wherein R_4 is an amino alkyl $R_{8'}R_{9'}NCH_2$-, in which $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen; C_1-C_8alkyl, cyclopentyl, cyclohexyl, C_5- or C_6cycloalkylmethyl, phenyl-C_1-C_4alkyl or phenyl-C_2-C_4alkenyl.

37. A compound according to claim 32, wherein R_4 is an amine $R_{8'}R_{9'}NCH_2$-, where $R_{8'}$ and $R_{9'}$ are, independently of one another, H, C_1-C_6alkyl, phenyl-C_1- or -C_2alkyl.

38. A compound according to claim 26, wherein R_4 is C_7-C_{11}aralkyl, C_3-C_{12}cycloalkyl or C_1-C_{12}alkyl, which is unsubstituted or substituted by one or more substituents selected from the group consisting of NH_2, C_3-C_{12}cycloalkyl, primary amino, secondary amino, sulfonamide and carbamide and aminocarbonylamido.

39. A compound according to claim 38, wherein the substituents for C_1-C_{12}alkyl are selected from the group consisting of NH_2, cyclohexyl, C_6-C_{10}aryl, $R_8C(O)N(R_9)$-, $R_8S(O)_2N(R_9)$-, $R_8NHC(O)NR_9$- and $R_{8'}R_{9'}N$-, in which R_8 and R_9 are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, OH, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl,

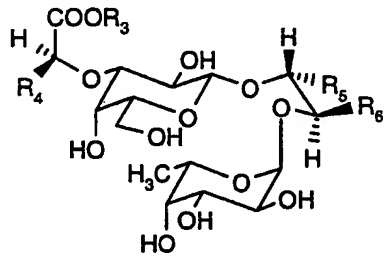
C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11} aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; p is 0 or 1 and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal; or $R_{8'}$ and $R_{9'}$ together are tetramethylene, pentamethylene, $-(CH_2)_2-O-(CH_2)_2-$, $-(CH_2)_2-S-(CH_2)_2-$ or $-(CH_2)_2-NR_7-(CH_2)_2-$, and R_7 is H, C_1-C_6alkyl, C_7-C_{11}aralkyl, $C(O)R_{s2}$ or sulfonyl.

40. A compound according to claim 39, wherein R_4 is CH_2-C_6H_5, $(CH_2)_2$-C_6H_5, cyclohexyl, methyl, ethyl or isopropyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of NH_2, cyclohexyl, C_6-C_{10}aryl, $R_8C(O)N(R_9)$-, $R_8S(O)_2N(R_9)$-, $R_8NHC(O)NR_9$-, $NR_9C(O)NHR_8$ and R_8R_9N-, in which R_8, R_9, $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OM_y$, nitro, cyano, SO_3M_y, OSO_3M_y, $NHSO_3M_y$, C_1-C_{12}alkyl, C_1-C_{12}alkoxy and C_6-C_{10}aryl, where y is 1 and M is a monovalent metall or y is 1/2 and M is a divalent metal.

41. A compound according to claim 26, wherein R_4 is C_6H_{11}, $CH(CH_3)_2$, CH_2-phenyl, $(CH_2)_2$-phenyl, $CH_2NHC(O)$-phenyl, $CH_2NHC(O)(CH_2)_3$-phenyl, $CH_2NHC(O)(CH_2)_3OH$, $CH_2NHC(O)CF_3$, $CH_2NHC(O)C_6H_{11}$, $CH_2NHC(O)C_{11}H_{23}$, $CH_2NHC(O)CH(C_6H_5)_2$, $CH_2HNC(O)NHC_6H_5$, $CH_2NHC(O)C_2H_4CO_2Na$, $CH_2NHC(O)C_6[(1,3,4,5)OH]_4H_7$, $CH_2NHC(O)C_6H_4$-p-SO_3Na, $CH_2NHC(O)C_6H_4Cl$, $CH_2NHC(O)C_6H_4NO_2$, $CH_2NHC(O)C_6H_4OCH_3$, $CH_2NHC(O)C_6H_4(3,4)Cl_2$, $CH_2NHC(O)C_6H_4CH_3$,

$CH_2NHC(O)C_6H_4C_6H_5$, $CH_2NHC(O)C_6H_4CN$, $CH_2NHC(O)C_{10}H_7$, $CH_2NHC(O)C_6H_4COONa$, $CH_2NHC(O)(CHOH)_2COONa$, $CH_2N(CH_2CH=CH\text{-phenyl})[C(O)\text{-phenyl}]$, $CH_2N[CH_2CH(CH_3)_2][C(O)\text{-phenyl}]$, $CH_2N[C(O)C_6H_5]CH_2C_6H_5$, $CH_2N[C(O)C_6H_5](CH_2)_3C_6H_5$, $CH_2C_6H_{11}$, $(CH_2)_2C_6H_{11}$, CH_2NH_2, $CH_2NHCH_2CH=CH\text{-phenyl}$, $CH_2NHCH_2\text{-phenyl}$, $CH_2NHCH_2CH(CH_3)_2$, $CH_2N(CH_2\text{-phenyl})_2$, $CH_2N[CH_2CH(CH_3)_2]_2$, $CH_2NHSO_2\text{-p-nitrophenyl}$, $CH_2NHSO_2\text{-p-tolyl}$, $CH_2NHSO_2CF_3$, $CH_2NHC(O)NHC_6H_5$ or $CH_2N[SO_2\text{-p-nitrophenyl}][CH_2CH(CH_3)_2]_2$.

42. A compound according to claim 1, which corresponds to the formula Ia



in which

R_3 is hydrogen or M_y; and

R_4 is C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl or C_7-C_{10}heteroaralkenyl, which are unsubstituted or substituted once or several times;

R_5 and R_6 are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl; or

R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_4-C_{12}cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group of -O-, -S- and -N-;

where alkyl, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkylene, cycloalkenylene, heterocycloalkylene and heterocycloalkenylene are unsubstituted or substituted once or several times; where the substituent is selected from the group OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}hetero-

cycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are substituted or unsubstituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is a 1/2 and M is a divalent metal.

43. A compound according to claim 42, wherein R_3 is H, K or Na; R_5 and R_6 are, together with the -CH-CH- group, C_3-C_{12}cycloalkylene, C_4-C_{12}cycloalkenylene, C_2-C_{11}heterocycloalkylene and C_3-C_{11}heterocycloalkenylene with hetero atoms selected from the group -O-, -S- and -N-; which are unsubstituted or substituted once or several times; where the substituent is selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, in which R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocyclo-

alkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal;

(a) R_4 is a residue R_{12}-$(CH_2)_n$- or cyclohexyl, in which n is 1 or 2 and

R_{12} is C_1-C_{10}alkyl, C_5-C_8cycloalkyl, C_6-C_{10}aryl or C_8-C_{12}aralkenyl, which are unsubstituted or substituted by C_1-C_4alkyl, C_1-C_4alkoxy, F, Cl, -CN or -NO_2; or

R_{12} is an amino group -$NR_{8'}R_{9'}$, and $R_{8'}$ and $R_{9'}$ are C_1-C_{12}alkyl or unsubstituted or C_1-C_4alkyl-substituted C_5- or C_6cycloalkyl, C_6-C_{10}aryl, C_7-C_{12}aralkyl or C_8-C_{12}aralkenyl; or

R_{12} is an amide group -$N(R_9)C(O)R_8$, -$N(R_9)S(O)_2R_8$, -$NR_9C(O)NHR_8$ or -$NR_9C(O)NHR_8$ in which R_8 is C_6-C_{10}aryl, which is unsubstituted or substituted by C_1-C_4alkyl, C_1-C_4alkoxy, F, Cl, -CN or -NO_2, or C_1-C_{10}alkyl which is unsubstituted or substituted by F or Cl, and R_9 is H, C_1-C_{10}alkyl, C_5- or C_6cycloalkyl, C_5- or C_6cycloalkyl-C_1-C_6alkyl, phenyl-C_1-C_6alkyl or phenyl-C_2-C_6alkenyl; or

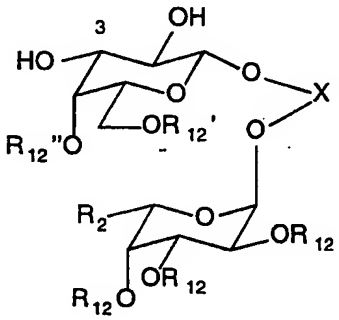
(b) R_4 is C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

44. A compound according to claim 43, wherein
(i) R_4 is C_6H_{11}, C_6H_{11}-CH_2, C_6H_{11}-CH_2CH_2-, C_6H_5-CH_2-, C_6H_5-CH_2CH_2- or C_6H_5-CH=CH-CH_2-;
(ii) R_4 is C_6H_{11}, C_6H_{11}-CH_2-, C_6H_{11}-CH_2CH_2-, C_6H_5-CH_2-, C_6H_5-CH_2CH_2-, -CH_2-NR_{19}-SO_2R_{18}, -CH_2-NR_{19}-$C(O)R_{40}$, $CH_2NHC(O)NHR_{18}$, -CH_2NHR_{21} or $CH_2N(R_{21})_2$, in which R_{18} is -C_6H_5, phenyl which is substituted by 1 to 3 methyl or methoxy or -NO_2 or F or Cl, or C_1-C_4alkyl, which is substituted by F; R_{40} is phenyl which is unsubstituted or substituted by 1 to 3 methyl or methoxy or -NO_2 or F or Cl; R_{19} is H, C_1-C_6alkyl, phenyl-$(CH_2)_z$- with z equal to a number from 1 to 3, phenyl-CH=CH-CH_2-, -CH_2-$CH(CH_3)_2$ or benzyl; and R_{21} is -CH_2-$CR_{22}R_{23}R_{24}$ in which R_{22} and R_{23}, methyl, ethyl or phenyl and R_{24} is H, ethyl or methyl; or
(iii) R_4 is C_6H_{11}, CH_2-C_6H_5, $(CH_2)_2$-C_6H_5, methyl, ethyl or isopropyl, which are unsubstituted or substituted by one or more substituents selected from the group consisting of NH_2, cyclohexyl, C_6-C_{10}aryl, $R_8C(O)N(R_9)$-, $R_8S(O)_2N(R_9)$-, $NR_9C(O)NHR_8$ and R_8R_9N- in which R_8, R_9, $R_{8'}$ and $R_{9'}$ are, independently of one another, hydrogen, C_1-C_{12}alkyl, C_3-C_{12}cycloalkyl, C_6-C_{10}aryl or C_7-C_{11}aralkyl which are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OM_y$, nitro, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_1-C_{12}alkoxy and C_6-C_{10}aryl, where R_{20} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}-heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal.

45. A compound according to claim 42, wherein R_4 is C_6H_{11}, $CH(CH_3)_2$, CH_2-phenyl, $(CH_2)_2$-phenyl, $CH_2NHC(O)$-phenyl, $CH_2NHC(O)(CH_2)_3$-phenyl, $CH_2NHC(O)(CH_2)_3OH$, $CH_2NHC(O)CF_3$, $CH_2NHC(O)C_6H_{11}$, $CH_2NHC(O)C_{11}H_{23}$, $CH_2NHC(O)CH(C_6H_5)_2$, $CH_2HNC(O)NHC_6H_5$, $CH_2NHC(O)C_2H_4CO_2Na$, $CH_2NHC(O)C_6[(1,3,4,5)OH]_4H_7$, $CH_2NHC(O)C_6H_4$-p-SO_3Na, $CH_2NHC(O)C_6H_4Cl$, $CH_2NHC(O)C_6H_4NO_2$, $CH_2NHC(O)C_6H_4OCH_3$, $CH_2NHC(O)C_6H_4(3,4)Cl_2$, $CH_2NHC(O)C_6H_4CH_3$, $CH_2NHC(O)C_6H_4C_6H_5$, $CH_2NHC(O)C_6H_4CN$, $CH_2NHC(O)C_{10}H_7$, $CH_2NHC(O)C_6H_4COONa$, $CH_2NHC(O)(CHOH)_2COONa$, $CH_2N(CH_2CH=CH$-phenyl)[C(O)-phenyl], $CH_2N[CH_2CH(CH_3)_2][C(O)$-phenyl], $CH_2N[C(O)C_6H_5]CH_2C_6H_5$, $CH_2N[C(O)C_6H_5](CH_2)_3C_6H_5$, $CH_2C_6H_{11}$, $(CH_2)_2C_6H_{11}$, CH_2NH_2, $CH_2NHCH_2CH=CH$-phenyl, CH_2NHCH_2-phenyl, $CH_2NHCH_2CH(CH_3)_2$, $CH_2N(CH_2$-phenyl$)_2$, $CH_2N[CH_2CH(CH_3)_2]_2$, CH_2NHSO_2-p-nitrophenyl,

CH_2NHSO_2-p-tolyl, $CH_2NHSO_2CF_3$, $CH_2NHC(O)NHC_6H_5$ or $CH_2N[SO_2$-p-nitrophenyl$][CH_2CH(CH_3)_2]_2$.

46. A process for the preparation of the compounds of the formula I according to claim 1 which comprises etherifying the 3-OH group of a compound of the formula V



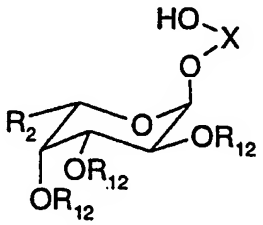
(V)

in which R_2 and X have the meanings mentioned in claim 1, R_{12} is a protective group and R_{12}' and R_{12}" are, independently of one another, hydrogen or a protective group, with a compound of the formula VI

$$R_1\text{-}R_{13} \qquad \text{(VI)}$$

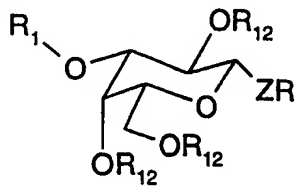
in which R_1 has the meaning mentioned in claim 1 and R_{13} is a leaving group, and eliminating the protective groups.

47. A process for the preparation of the compounds of the formula I according to claim 1 which comprises glycosidically linking the protected fucose hydroxy ether of the formula VII



(VII),

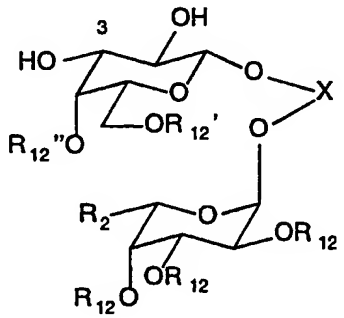
in which R_2 and X have the meanings mentioned in claim 1, and R_{12} is a protective group, with the protected galactose of the formula VIII



(VIII),

in which R_1 and R_{12} have the meanings mentioned in claim 1, Z is O or S, and R is a leaving group, and subsequently removing the protective groups from the resulting compound.

48. A compound of the formula V



(V)

in which

X is the residue of a non-glycosidic aliphatic 1,2-diol;

R_2 is hydrogen, C_1-C_{12}alkyl or C_6aryl; where the alkyl and the aryl are unsubstituted or substituted by one or more substituents selected from the group consisting of OH, halogen, $C(O)OR_{s1}$, $OC(O)R_{s4}$, $C(O)R_{s2}$, nitro, NH_2, cyano, SO_3M_y, OSO_3M_y, $NR_{20}SO_3M_y$, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_1-C_{12}alkoxy, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_6-C_{10}aryloxy, C_5-C_9heteroaryl, C_5-C_9heteroaryloxy, C_7-C_{11}aralkyl, C_7-C_{11}aralkyloxy, C_6-C_{10}heteroaralkyl, C_8-C_{11}aralkenyl, C_7-C_{10}heteroaralkenyl, primary amino, secondary amino, sulfonyl, sulfonamide, carbamide, carbamate, sulfonhydrazide, carbhydrazide, carbohydroxamic acid and aminocarbonylamide, where R_{s1} is hydrogen, M_y, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl,

C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, R_{s4} is hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_2-C_{11}heterocycloalkyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl or C_6-C_{10}heteroaralkyl, and R_{s2} and R_{20} are hydrogen, C_1-C_{12}alkyl, C_2-C_{12}alkenyl, C_3-C_{12}cycloalkyl, C_3-C_{12}cycloalkenyl, C_2-C_{11}heterocycloalkyl, C_2-C_{11}heterocycloalkenyl, C_6-C_{10}aryl, C_5-C_9heteroaryl, C_7-C_{11}aralkyl, C_6-C_{10}heteroaralkyl, C_8-C_{11}-aralkenyl or C_7-C_{10}heteroaralkenyl, and alkyl, alkenyl, alkoxy, cycloalkyl, cycloalkenyl, heterocycloalkyl, heterocycloalkenyl, aryl, aryloxy, heteroaryl, heteroaryloxy, aralkyl, aralkyloxy, heteroaralkyl, aralkenyl and heteroaralkenyl in turn are unsubstituted or substituted by one of the abovementioned substituents; and y is 1 and M is a monovalent metal or y is 1/2 and M is a divalent metal;
R_{12} is a protective group and R_{12}' and R_{12}" are, independently of one another, hydrogen or a protective group.

49. A process for the preparation of a compound of the formula V according to claim 48 which comprises initially synthesizing pseudo-trisaccharide building blocks by glycosidic attachment for the activated and protected galactose to the fucose-O-X-OH building block or by glycosidic attachment of suitably protected and activated fucose to a galactose-O-X-OH building block, then introducing the group R_1 into the pseudotrisaccharide and subsequently modifying the resulting compounds in the desired manner.

50. A compound according to claim 1, for use in a therapeutic method for the treatment of disorders in warm-blooded animals, including humans.

51. A pharmaceutical composition comprising an effective amount of the compound according to claim 1, alone or together with other active substances, a pharmaceutical carrier, and, where appropriate, excipients.

INTERNATIONAL SEARCH REPORT

Internatio ' Application No
PCT/Lr 96/02785

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C07H15/207 C07H17/02 A61K31/70

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C07H A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, vol. 117, no. 19, 17 May 1995, DC US, pages 5395-5396, XP002020092 UCHIYAMA T ET AL: "Design and Synthesis of Sialyl Lewis X Mimetics" see the whole document ---	1
A	TETRAHEDRON LETTERS, vol. 36, no. 13, 27 March 1995, OXFORD GB, pages 2339-2342, XP002020093 PRODGER J C ET AL: "Synthesis of a novel analog of sialyl Lewis X" see page 2340 --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 December 1996	10. 12. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Day, G

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/Er 96/02785

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	TETRAHEDRON LETTERS, vol. 36, no. 50, December 1995, OXFORD GB, pages 9161-9164, XP000569681 TOEPFER A ET AL: "Synthesis of novel mimetics of the sialyl Lewis X determinant" see the whole document	42
A	EP 0 579 196 A (THE NISHIN OIL MILLS LTD) 19 January 1994 cited in the application see page 13	1
A	WO 93 10796 A (GLYCOMED, INC.) 10 June 1993 cited in the application see claims	1
A	WO 93 23031 A (THE BIOMEMBRANE INSTITUTE) 25 November 1993 cited in the application see figure 11	1

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